APPLIED MECHANICS Reviews

A CRITICAL REVIEW OF THE WORLD LITERATURE IN APPLIED MECHANICS AND RELATED ENGINEERING SCIENCE

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GENERAL

Theoretical and Experimental Methods.. 355
Mechanics (Dynamics, Statics, Kinematics) 359

MECHANICS OF SOLIDS

Gyroscopics, Governors, Servos..... 361
Vibrations, Balancing..... 361
Wave Motion, Impact..... 364
Elasticity Theory..... 365
Experimental Stress Analysis..... 366
Rods, Beams, Shafts, Springs, Cables, etc. 367
Plates, Disks, Shells, Membranes..... 367
Buckling Problems..... 369
Structures..... 369
Rheology (Plastic, Viscoplastic Flow).... 371
Failure, Mechanics of Solid State..... 372
Material Test Techniques..... 373
Mechanical Properties of Specific Materials..... 374
Mechanics of Forming and Cutting..... 376

MECHANICS OF FLUIDS

Hydraulics; Cavitation; Transport..... 377
Incompressible Flow: Laminar; Viscous.. 377
Compressible Flow, Gas Dynamics..... 378
Turbulence, Boundary Layer, etc..... 380
Aerodynamics of Flight; Wind Forces.. 381
Aeroelasticity (Flutter, Divergence, etc.). 383
Propellers, Fans, Turbines, Pumps, etc... 383
Flow and Flight Test Techniques..... 384

HEAT

Thermodynamics..... 385
Heat and Mass Transfer..... 387

MISCELLANEOUS

Acoustics..... 388
Ballistics, Detonics (Explosions)..... 389
Soil Mechanics, Seepage..... 389
Micromeritics..... 390
Geophysics, Meteorology, Oceanography 391
Lubrication; Bearings; Wear..... 392
Marine Engineering Problems..... 392

Communications, 355

Aircraft Structural Research—A Critical Survey, D. Williams, 353

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APPLIED MECHANICS REVIEWS

VOL. 6, NO. 8 MARTIN GOLAND *Editor* AUGUST 1953

AIRCRAFT STRUCTURAL RESEARCH—A CRITICAL SURVEY

D. WILLIAMS

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IN RECENT years aeronautical structural research, both analytical and experimental, has been trying to catch up with the design innovations that are becoming a regular feature of aircraft structural development. In this attempt two avenues have been continuously explored, one leading to the discovery of new methods of approach, and the other to the better exploitation of existing methods.

EXPERIMENTAL METHODS

Among experimental methods, that of measuring stresses by means of the resistance strain gage must be regarded as by far the most fruitful new method developed in recent years, and for obtaining the complete stress distribution in a complicated structure it has no alternative. As a good example of the better exploitation of an older technique, the method of photoelasticity may be mentioned. The stresscoat method has not proved very popular, largely because of its unreliability in the matter of obtaining quantitative results, although its use recently at the Royal Aircraft Establishment in solving a helicopter-hub problem suggests that it can be extremely useful for certain types of work. Both the photoelasticity and the stresscoat methods are of restricted use in that they are normally applicable only to small structural elements. Experimental work based on analogies, in spite of its attractive appeal, does not seem to be pursued to any great extent. No one these days, for example, would think of using the soap-bubble analogy for serious experimental work. The demand is for something more easily handled, which is why certain electrical analogies (1),[1] requiring only the measurement of change of potential, still have their protagonists.

A traditional method of approach to structural problems, and one that has lost none of its potentialities, is the approach via a small-scale model of the actual structure. Scaled models of complete structures are seldom used for measuring strength or stress distribution, but are mostly used for obtaining the dynamical characteristics of a structure—the normal modes and the natural frequencies of vibration. Stress measurements, to be reliable, require the model to be too faithful a copy of the original structure to make it a practical proposition, but the dynamical characteristics can be measured so long only as the stiffness and inertia values are correctly represented. It has been suggested (2) that a simplified model can be made on the basis of a completely separate representation of the stiffness and the inertia characteristics. The model is first made with the stiffness alone in mind and without concern for the inertia of the structural elements; the correct mass distribution is then superimposed by using masses that dwarf those of the structural elements themselves. An important advantage of the experimental approach by way of a representative model is that, unlike other such approaches, it can be used to aid design and not merely to check it.

THEORETICAL METHODS

With regard to theoretical methods, much more has been done in the way of improving and adapting well-known methods than in the invention of new methods. The most important, if not the only genuinely new approach is the relaxation method of Southwell, which has in recent years gathered to itself an extensive literature and an impressive record of successful application to the solution of problems in engineering (3) and physics (4). An attractive feature of the method is the scope it allows the computer for guiding the process of successive approximations so as to reach the required solution in the least possible number of steps—an important consideration when only elementary computing equipment is available.

Another method devised to reduce the complexity of a structural problem is that of "mechanical admittances." Borrowed from electrical practice and adapted for dealing with mechanical vibrations, the method was first used by Carter (5) and later rationalized and developed by Duncan (6). Here again the main objective is the reduction of a problem to a form that is manageable without involving elaborate computing aids.

Of the older established methods little use is now made of the classical approach via stress functions, and the accent is heavily on the use of energy methods. Of the latter, the once dominant position of Castigliano's least-work theorem (7) has been usurped by the more versatile principle of "minimum total potential energy" (7) with its independence of Hooke's law and its more convenient starting point of an assumed type of displacement rather than an assumed stress distribution. Solutions to structural stability problems, whether obtained by relaxation or more orthodox methods, have nearly all been based on this principle. In vibration problems Rayleigh's principle (8), with its various adapta-

[1] Numbers in parentheses refer to References at end of paper.

tions, is the main standby in current investigations into the dynamical characteristics of airplane structures, whether the computational equipment is a slide rule or an electronic computing machine. For structures that are not too complicated, however, Myklestad's (9) adaptation of the Holzer method has its advantages.

At one time the evaluation of the natural frequencies and modes of a structure by the combined use of influence coefficients and matrix iteration offered no substantial advantage over various other methods of successive approximation, but the advent of powerful high-speed digital computers such as the SEAC of the Bureau of Standards and the ACE of the National Physical Laboratory has revolutionized the position. With these machines available it is no longer so necessary to restrict the size of the flexibility matrix, and the use of matrices having 30 elements per side is becoming common. Once the formidable task of evaluating the deflection coefficients that form the elements of the matrix is accomplished, the machine grinds out the frequencies and modes in an astonishingly short time. It is clear from the references given by workers in this field that they are nearly all indebted for their introduction to matrix methods to the book on this subject by Frazer, Duncan, and Collar (10). The writer feels, however, that there is need for a smaller version that could bridge the gap between this and the admirable but all too short account of matrix methods included by von Kármán and Biot in their book (11). Closely akin to the matrix iteration method is the "escalator" method of Morris (12).

In the matter of applying the "normal mode" method for obtaining the response of a structure to transient forces, the recently introduced method of "segregation of inertia forces" (13) has greatly simplified and improved the accuracy of the customary procedure.

PARTICULAR PROBLEMS

The advent of stressed-skin construction in the early 1930's brought with it a host of new problems, among which may be mentioned the effect of shear lag, the instability of stringer-reinforced panels, and the stresses induced by the warping of wing cross sections. The general methods of dealing with such problems are now well established, and only minor departures from standard procedures are involved in applying the methods to individual cases.

The use of sandwich construction, pioneered by the de Havilland Company, has given rise to a number of theoretical treatments in England, Holland, and the United States, from which (14–19) are arbitrarily chosen.

CURRENT PROBLEMS

The most important current problem is bound up with two recent innovations in airplane design—the introduction of new planforms for wings, and the use of very thin wings. Swept, delta, and crescent wings under static and dynamic loads present structural problems of considerable difficulty to the designer, and these are made still more difficult by the small thickness-chord ratio required for low drag at high speed. A comprehensive review of recent work on swept wings under static loading has been given by M. L. Williams (20). This covers both the theoretical and the experimental approach for both thick and thin wings. The good agreement obtained by Redshaw and Palmer (21)—and noted by Williams—between the static stresses and vibration modes of a full-size delta wing and those of a plastic model well demonstrates the power and convenience of this experimental approach.

To the engineer the "intuitive" analytical approach to the swept-wing problem consists in treating the root triangle and the outboard portion as separate structural units, whose stresses and displacements at their common boundary are finally reconciled. Lang and Bisplinghoff (22) suggest making this reconciliation by employing the principle of minimum-total-potential-energy. For static loadings such a method is probably as good as any, but for dynamic loads, and particularly where the higher vibration modes are concerned, it is inadequate because, as in the case of the unswept wing, it fails to take account of shear lag. In a two-spar, stringer-reinforced wing the interspar stringers are practically out of action in the higher bending modes, so that, if they are included, a serious overestimate of the wing stiffness, and therefore of the frequencies, can be made.

This and other difficulties suggested to Levy (23) the idea of calculating the modes and frequencies of wings of irregular planform by the use of deflection (or influence) coefficients unrelated to the notion of a flexural axis. The matrix iteration method is used, and therefore the main concern is the evaluation of the deflection coefficients, the remainder of the work—the matrix iteration—being relegated to the machine. In essence, Levy's method for this is to express the total strain energy U of the structure as a homogeneous quadratic function of specified loads $P_1, P_2, \ldots P_n$ (applied at the n stations at which are located the n discrete masses into which the total mass of the structure is divided) and assumed loads $Q_1, Q_2, \ldots Q_n$ in the redundant members of the structure. Equations of the form $\partial U/\partial Q_r = 0$ (by Castigliano's theorem of least work) gives all the Q's, so tht U becomes a function of the P's alone. The n deflection coefficients involving station 1, i.e., $a_{11}, a_{12}, \ldots a_{1n}$ (where a_{1r} signifies the deflection at station 1 due to unit load at r) are then obtained directly as the coefficients of the loads $P_1, P_2, \ldots P_n$ in the partial differential $\partial U/\partial P_1$, in accordance with Castigliano's second theorem. The n coefficients for any other station r are similarly obtained from the partial differential $\partial U/\partial P_r$, thus finally obtaining the n^2 elements of the flexibility matrix. Theoretically this method has the great merit of dealing with the twin difficulties of shear lag and cross-sectional warping in its stride, the former by introducing one or more effective interspar stringers (at the cost of adding to the number of redundancies), and the latter by introducing a set of self-equilibrating warping forces at the root and at each of the imaginary sections by which the wing is arbitrarily divided, thus still further increasing the redundant Q forces. The actual procedure advocated by Levy is somewhat different from the above outline, in that he obtains his deflections directly from the applied forces and not via a strain-energy function. He also neglects stresses due to cross-sectional warping except those at the wing root.

When we leave behind the familar wing construction of spars and stringer-reinforced skin and have to consider thin, near-solid wings, neither the stress distribution nor the type of deformation of the loaded structure is easy to visualize. A fair amount of work has been done in this direction, much of it on the simple case of the flat plate of uniform thickness. M. L. Williams (20) covers most of this work in his review. It is easy to see that the very thin wing is going to introduce some very difficult problems, not least of which is that connected with the curvature of wing sections in the line of flight, affecting as it does the distribution of the aerodynamic loads themselves and hence the stability of the aircraft. At the moment such problems are "terra incognita."

The following references are those that naturally came to mind in writing this article. They represent only a small fraction of work that has recently appeared in, among others, the following publications: (a) *Rep. and Mem.* Series of the ARC; (b) Reports and Technical Notes of the NACA; (c) *Journal of the Aeronautical Sciences;* (d) *Journal of the Royal Aeronautical Society;* (e) *Aeronautical Quarterly of the Royal Aeronautical Society;* (f) *Journal of Applied Mechanics;* and (g) *Aircraft Engineering.*

REFERENCES

1 Redshaw, S. C., An electrical potential analyser, *Instn. mech. Engrs. appl. Mech.* (*W.E.P.* 38) **159**, p. 55, 1948.

2 Williams, D., Note on the distortion characteristics of swept and cranked wings in relation to flutter and other aeroelastic phenomena, AMR **4**, Rev. 2900.

3 Southwell, R. V., Relaxation methods in engineering science, London, New York, Oxford Univ. Press, 1940.

4 Southwell, R. V., Relaxation methods in theoretical physics, London, New York, Oxford Univ. Press, 1946.

5 Carter, B. C., The mounting of aero engines: Transverse and whirling vibrations of some idealized systems analyzed by applying the method of admittances as extended by Duncan, *Aero. Res. Counc. Lond. Rep. Mem.* 1988, July 1941.

6 Duncan, W. J., Mechanical admittances and their applications to oscillation problems, *Aero. Res. Counc. Lond. Rep. Mem.* 2000, 1947.

7 Williams, D., The relations between the energy theorems applicable in structural theory, *Phil. Mag.*, Nov., 1938.

8 Temple, G., and Bickley, W. G., Rayleigh's principle, London, New York, Oxford Univ. Press, 1933.

9 Myklestad, N. O., Vibration analysis, New York, McGraw-Hill, 1944.

10 Frazer, R. A., Duncan, W. J., and Collar, A. R., Elementary matrices, London, New York, Cambridge Univ. Press, 1946.

11 von Kármán, T., and Biot, M. A., Mathematical methods in engineering, New York, McGraw-Hill, 1940.

12 Morris, J., The escalator process, London, Chapman & Hall, 1947.

13 Williams, D., Displacements of a linear elastic system under a given transient load, AMR **3**, Rev. 2201.

14 Williams, D., Leggett, D. M. A., and Hopkins, H. G., Flat sandwich panels under compressive end loads, *Aero. Res. Counc. Lond. Rep. Mem.* 1987, 1941.

15 Williams, D., Sandwich construction—a practical approach for the use of designers, *Aero. Res. Counc. Lond. Rep. Mem.* 2466, 1951.

16 van Wijngaarden, A., The elastic stability of flat sandwich plates, AMR **1**, Rev. 1115.

17 Plantema, F. J., and De Kock, A. C., The elastic overall instability of sandwich plates with simply supported edges, AMR **3**, Rev. 2291.

18 Libove, C., and Batdorf, S. B., A general small-deflection theory for flat sandwich plates, AMR **1**, Rev. 799.

19 Teichman, F. K., Wang, C. T., and Gerard, G., Buckling of sandwich cylinders under axial compression, AMR **4**, Rev. 4122.

20 Williams, M. L., A review of certain analysis methods for swept-wing structures, AMR **6**, Rev. 1879.

21 Redshaw, S. C., and Palmer, P. J., The construction and testing of a Xylonite model of a delta wing, AMR **5**, Rev. 885.

22 Lang, A. L., and Bisplinghoff, R. L., Some results of swept-back wing structural studies, AMR **5**, Rev. 1371.

23 Levy, S., Computation of influence coefficients for aircraft structures with discontinuities and sweepback, AMR **1**, Rev. 79.

Communications

Concerning feature article, AMR 6 (April 1953): O. Bottema, Recent work on kinematics

I should like to call attention to the following excellent reference, omitted from my feature article because of its recent issue:

Grodzinski, P., Theory of mechanisms. I. Geometrical principles [Getriebelehre. I. Geometrische Grundlagen], 2nd ed., Berlin, Sammlung Göschen Bd. 1061, 1953, 159 pp. [AMR **6**, Rev. 1494].

O. Bottema, Holland

Concerning AMR 6, Rev. 1254 (April 1953):

Authors' names should read Hu, L. W., and Marin, J.

Mr. Hu has written to state that the review gives the impression that the experimental data reported in this article are taken from a paper by Marin and Kotalik, AMR **4**, Rev. 2929. This is not the case, and the experimental results will soon be published in an *ASTM* report.

Ed.

Concerning AMR 6, Rev. 2059 (June 1953): Truesdell, C., Critical length for the propagation of free waves in a viscous fluid

In my review, in the equation for critical wave length the symbol V was left out. The correct equation is: $l_c = \pi V\mu/\rho V_0$.

V. G. Szebehely, USA

Theoretical and Experimental Methods

(See also Rev. 2446)

2389. Viswanatham, B., On the asymptotic behaviour of solutions of non-linear equations, *Proc. Indian Acad. Sci.* (*A*) **36**, 5, 335–342, Nov. 1952.

This paper gives some new theorems on the boundedness and asymptotic stability of solutions of nonlinear differential equations.

G. W. King, USA

2390. Rachajsky, M. B., Application of characteristic functions in the geometrical theory of characteristics (in French), *Acad. roy. Belgique Bull. Cl. Sci.* (5) **38**, 536–546, 1952.

Considering the first-order differential equation

$$F(x, y, z, p, q) = 0, \quad F_p \not\equiv 0$$

necessary and sufficient conditions are discussed which must be satisfied to construct geometrically complete integrals $Z = f(x, y, C_1, C_2)$, eliminating C_3 from the relations

$$y = \varphi(x, C_1, C_2, C_3) \text{ and } z = \psi(x, C_1, C_2, C_3)$$

Similarly, are discussed the differential equation

$$F(x_1, \ldots, x_n, z, p_1, \ldots, p_n) = 0, \quad F_{p_1} \not\equiv 0$$

and the system in involution

$$F_k(x_1, \ldots, x_n, z, p_1, \ldots, p_n) = 0$$

$$\Delta = \frac{\partial(F_1, \ldots, F_m)}{\partial(p_1, \ldots, p_m)} \not\equiv 0, \quad [F_k, F_s] = 0, \quad k, s = 1, 2, \ldots, m < n.$$

Courtesy of Mathematical Reviews M. Pinl, India

2391. Lichnerowicz, A., and Aufenkamp, D., The general problem of the transformation of the equations of dynamics, *J. rational Mech. Analysis* **1**, 499–520, 1952.

Let two dynamical systems be given by the following equations of motion

$$\frac{d^2x^\alpha}{dt^2} + \Gamma^\alpha{}_{\gamma\beta}\frac{dx^\gamma}{dt}\frac{dx^\beta}{dt} + a_\beta{}^\alpha\frac{dx^\beta}{dt} = Q^\alpha \qquad [D]$$

$$\frac{d^2x^\alpha}{d\tau^2} + \Lambda^\alpha{}_{\gamma\beta}\frac{dx^\gamma}{d\tau}\frac{dx^\beta}{d\tau} + b_\beta{}^\alpha\frac{dx^\beta}{d\tau} = R^\alpha \qquad [E]$$

where $\Gamma^\alpha{}_{\gamma\beta}$ and $\Lambda^\alpha{}_{\gamma\beta}$ are the Christoffel symbols relative to the tensors $g_{\alpha\beta}$ and $h_{\alpha\beta}$, and $g_{\alpha\gamma}a_\beta{}^\gamma$ and $h_{\alpha\gamma}b_\beta{}^\gamma$ are both skew-symmetric. What are the conditions in order that the trajectories of the two systems be identical? In solving this problem, the authors are led to distinguish two cases: a singular case, which appears to be identical with the case for which T. Y. Thomas solved the problem [*J. Math. Phys* **25**, 191–208, 1946], and a general case. It is shown that if in the general case (and not in the special case) any path of [E] is a path of [D], the converse is also true.

Courtesy of Mathematical Reviews J. Haantjes, Holland

2392. Tolba, S. E., On the summability of Taylor series at isolated points outside the circle of convergence, *Proc. k. Ned. Akad. Wet.* (*A*) **55** = *Indagationes Math.* **14**, 380–387, 1952.

Let $f(z) = \Sigma c_n z^n$ be a Taylor series with radius of convergence

1, and let $z_1, \ldots, z_m$ be given regular points of $f(z)$ with $|z_k| > 1$. If the c_n and the z_k satisfy certain conditions, there is a regular matrix method of summation which sums $\Sigma c_n z^n$ (to the value $f(z)$) outside of $|z| = 1$ at exactly mp points $z_k \exp(2\pi li/p), k = 1, \ldots, m, l = 0, \ldots, p-1$. (Reviewer's remark: Darevsky [*Izv. Akad. Nauk SSSR Ser. Mat.* **10**, 97–104, 1946] proved the existence of a regular method summing exactly the sequences $as_n + t_n$ with an arbitrary unbounded s_n and convergent t_n. The question under which conditions the corresponding statement is true for m given sequences seems to be open.)

Courtesy of Mathematical Reviews G. G. Lorentz, Canada

2393. Berkovitz, L. D., On double trigonometric integrals, *Trans. Amer. math. Soc.* **73,** 345–372, 1952.

F. Wolf [*Univ. California Publ. Math.* (*N.S.*) **1,** 159–227, 1947] and A. Zygmund [*Ann. Math.* (2) **48,** 393–440, 1947] have proved the equiconvergence theorem: For a trigonometrical integral $-\int_{-\omega}^{\infty} e^{ixu} d\varphi(u)$ where $\varphi(u)$ is of bounded variation in any finite interval and satisfies some regularity conditions, there is a continuous function $\alpha(u)$ such that

$$-\int_{-\omega}^{\omega} e^{ixu} d\varphi(u) - \int_{-\omega}^{\omega} e^{ixu}\, \alpha(u) du \to 0 \quad (\omega \to \infty)$$

uniformly in any closed interval, and there is a trigonometrical series $\Sigma a_n e^{inx}$ such that

$$-\int_{-\omega}^{\omega} e^{ixu} d\varphi(u) - \sum_{n=-[\omega]}^{[\omega]} a_n e^{inx} \to 0 \quad (\omega \to \infty)$$

uniformly in any closed interval contained in $(0, 2\pi)$. The author extends this theorem to double trigonometrical integrals, using restricted and circular convergence. He also extends the theory of the formal product, the multiplication theorem, and the localization theorem to double trigonometrical integrals.

Courtesy of Mathematical Reviews S. Izumi, Japan

2394. Celleja, Pedro Pi, On the concept of the integral (in Spanish), *Rev. Soc. Cubana Cienc. Fis. Mat.* **3,** 1, 8–24, 1953.

Author presents a general survey on the wide variety of the modern extensions to the integral concept, their logical foundations, their mutual relations, their geometrical interpretations, and their principal applications. The existence of functions which are monotonic with reference to ternary Cantor spaces is illustrated by examples. The Stieltjes integral is analyzed on the basis of its definition and geometrical interpretation. The elementary theorems of integral calculus are illuminated in view of modern thoughts. Among them is the rule of integration by parts, the transformation of variables and limits of integration, and the first and second mean value theorem. The discussion of the extension of the integral concept to non-absolutely convergent integrals follows. Object of discussion becomes the Harnack integral and the advanced generalization of the integral concept due to Lebesgue. Further modern variations and generalizations of the integral are briefly characterized. Among these are the integral definitions due to Perron, Denjoy, Khintchine, and Young. M. A. Dengler, USA

2395. Sauer, R., Three-dimensional problems of the theory of characteristics of partial-differential equations (in German), *ZAMM* **30,** 347–356, 1950.

Author discusses the method of characteristics in three-dimensional problems with particular reference to gas dynamics. In the first part he treats problems which are essentially two-dimensional because of certain symmetries (e.g., axial symmetry) and then problems with approximate symmetry whose solutions can be considered linear perturbations of the symmetrical ones and can, therefore, also be treated by the two-dimensional method of characteristics. A discussion of these cases can also be found in earlier work of the author [e.g., "Einführung in die theoretische Gasdynamik," 2nd ed., AMR **4,** Rev. 4217]. In the second part the author considers problems which are properly three-dimensional and, after a general introduction to the theory of characteristics for hyperbolic differential equations in three independent variables, outlines the procedure in numerical solution of initial value problems by a method of finite differences analogous to that used in two-dimensional problems.

Courtesy of Mathematical Reviews D. Gilbarg, USA

2396. Grobman, D. M., Systems of differential equations analogous to linear ones (in Russian), *Doklady Akad. Nauk SSSR*(*N.S.*) **86,** 19–22, 1952.

The author considers the vector-matrix system of differential equations $dx/dt = Ax + f(t, x)$, where $f(t, 0) = 0$, $||f(t, x) - f(t, z)|| \leqq g(t)||x - z||$, $||x|| = \Sigma_{i=1}^{n} |x_i|$, and establishes under various assumptions concerning $g(t)$, connections between the asymptotic behavior of x and y as $t \to \infty$, where $dy/dt = Ay$. An investigation along similar lines is contained in a paper by the reviewer [*Trans. Amer. math. Soc.* **62,** 357–386, 1947].

R. Bellman, USA

2397. Yano, S., Note on Fourier analysis. XXXI. Cesàro summability of Fourier series, *Pacific J. Math.* **2,** 419–429, 1952.

Author proves the following theorem: Let

$$\sum_{1}^{\infty} (a_n \cos nx + b_n \sin nx)$$

be the Fourier series of a function $f \in L$. Then both series $\Sigma(a_n \cos nx + b_n \sin nx)n^{-\alpha}$ and $\Sigma(a_n \sin nx - b_n \cos nx)n^{-\alpha}$ $(0 < \alpha < 1)$ are summable $(C, -\alpha)$ almost everywhere. The author quotes a remark of A. Zygmund according to which this theorem can also be obtained directly from known results. The analogous theorem for double Fourier series is also proved. Finally, the author proves that the set E of points where the series $\Sigma(a_n \cos nx + b_n \sin nx)n^{-\alpha}$ is not summable $(C, -\alpha)$ is of $(1 - \alpha)$-capacity zero, if

$$\Sigma(a_n \cos nx + b_n \sin nx) \sim f \in L$$

The same result is true for the series

$$\Sigma(a_n \sin nx - b_n \cos nx)n^{-\alpha}$$

Courtesy of Mathematical Reviews R. Salem, USA

2398. Haacke, W., On the stability of a system of linear ordinary differential equations of periodic coefficients, which depend on parameters (in German), *Math. Z.* **56,** 65–79, 1952.

The system of differential equations under consideration is of the form $y'' + \lambda^2 R(x)y + \lambda A(x, \lambda)y = 0$. Here y is an n-dimensional column vector, λ is a large positive parameter, and $R(x)$ and $A(x, \lambda)$ are square complex-valued matrix functions of order n with period 2π in x. It is further assumed that $A(x, \lambda)$ possesses an asymptotic expansion of the form $A(x, \lambda) \sim \Sigma_{\rho=0}^{\infty} \lambda^{-\rho} A_\rho(x)$, and that $R(x) = \{\delta_{\mu\nu} r_\mu^2(x)\}$, with $r_\mu^2 \not\equiv r_\nu^2$ for $\mu \neq \nu$. The system is called stable if all its solutions are uniformly bounded on the whole real x-axis, i.e., if its characteristic roots σ_r $(r = 1, \ldots, 2n)$ are all distinct and of modulus 1. An asymptotic form, for large λ, of the characteristic equation whose roots are σ_r is calculated by means of explicit asymptotic expressions for a set of $2n$ independent solutions of the differential system. These solutions are found by using a result of Perron [S.-B. *Heidelberger Akad. Wiss.* **9A,** nos. 13, 15, 1918; **10A,** 6, 1919].

The generally highly restrictive stability condition is studied in further detail in the special case that $R(x)$ and $A(x, \lambda)$ are real and, in addition, even functions with respect to a point $x = a$. It is shown first that the system is unstable for all sufficiently large λ, if $r_\mu{}^2 < 0$ for some μ. If all $r_\mu{}^2$ are positive, the system turns out to be stable except for certain explicitly calculated λ-intervals of length $O(\lambda^{-1/2})$.

Courtesy of Mathematical Reviews W. Wasow, USA

2399. **Avakumović, V. G., On the eigenfunctions of the wave equation** (in German), *Acad. Serbe Sci. Publ. Inst. Math.* **4,** 95–96, 1952.

For an eigenvalue problem $\Delta U + \lambda U = 0$ in a domain S with $U = 0$ on the (sufficiently smooth) boundary of S, Carleman, and later Minakshisundaram, established the estimates

$$\sum_{\lambda_n \leqq \lambda} \phi_n{}^2(P) = C_k \lambda^{k/2} + o(\lambda^{k/2})$$

and, for $P \neq Q$

$$\sum_{\lambda_n \leqq \lambda} \phi_n(P)\phi_n(Q) = o(\lambda^{k/2})$$

where C_k is a well-determined constant. Now, the author claims, and very briefly proves by the use of a one-sided Tauberian theorem, that the formulas underlying these estimates permit one to replace the error term $o(\lambda^{k/2})$ by the much sharper one $O(\lambda^{(k-1)/2})$.

Courtesy of Mathematical Reviews S. Bochner

2400. **Turrittin, H. L., Asymptotic expansions of solutions of systems of ordinary linear differential equations containing a parameter,** Contrib. Theory Nonlinear Oscill. **2,** *Annals Math. Studies* no. 29, 81–116, 1952. $1.50.

A didactic paper on methods of solving systems of differential equations of the type

$$\epsilon^h(dX/dt) = A(t,\epsilon)X \qquad [1]$$

where h is a non-negative integer; ϵ is a small parameter; X is a vector

$$X = \begin{vmatrix} X_1(t,\epsilon) \\ X_2(t,\epsilon) \\ \cdots\cdots \\ \cdots\cdots \\ X_n(t,\epsilon) \end{vmatrix}$$

and the square matrix $A(t,\epsilon)$ has an asymptotic expansion

$$A(t,\epsilon) = \sum_{k=0}^{\infty} \epsilon^k A(t)$$

in the domain D, where $a \leq t \leq b$, and ϵ is in a regular region R of the complex ϵ-plane extending from the circle $|\epsilon| = \epsilon_1 > 0$ into the origin $\epsilon = 0$. All boundary points of R, except $\epsilon = 0$, belong to R. Trjitzinsky has indicated that such equations will have N independent vector solutions of a certain form. Primary objective of the paper is to give definite procedures for computing these formal solutions. Secondary objective is to show that these formal solutions are asymptotic solutions in the sense of Poincaré, which are then used to solve the nonhomogeneous equation corresponding to [1]. On the basis of six hypotheses which excludes cases where $|\epsilon|$ is small and t is in proximity of a "turning point," author gives methods for obtaining formal solutions for 8 cases of increasing complexity. This work has application to boundary-value problems and to nonlinear systems. J. P. Breslin, USA

2401. **Cafiero, F., On the inversion of the order of integration** (in Italian), *R. C. Sem. Mat. Univ. Padova* **21,** part 1, 58–63, 1952.

Author gives conditions for the formula

$$\int_G dx \int_H f(x, y)dy = \int_H dy \int_G f(x, y)dx; \quad G \subset I_1,\ H \subset I_2$$

These are: $f(x, y)$ is measurable over the rectangle $I_1 \times I_2$ with I_1: $a \leq x \leq b$ and I_2: $c \leq y \leq d$. $f(x, y)$ is summable in I_1 with respect to x and summable in I_2 with respect to y. One of the two a.m. integrals shall exist for all measurable subsets G and H. Then the other exists and their equality holds. This does not mean that $f(x, y)$ is summable over the rectangle.

H. Bückner, Germany

2402. **Hartman, P., On the zeros of solutions of second order linear differential equations,** *J. Lond. math. Soc.* **27,** 493–496, 1952.

Author considers the differential equation [1] $y'' + [\lambda - q(x)]y = 0$, where $q(x)$ is continuous for $x \geqq 0$, and $q(x) \to \infty$ as $x \to \infty$. He extends a theorem of Titchmarsh by showing that if q is a continuous, increasing, convex function, the number $N(\lambda)$ of zeros of a nontrivial solution $y(x)$ of [1] satisfies the condition $\pi N(\lambda) = \int_0^{\varphi(\lambda)} (\lambda - q)^{1/2}\, dx + O(1)$ as $\lambda \to \infty$. Here $q(\varphi(\lambda)) = \lambda$.

Courtesy of Mathematical Reviews W. Leighton

2403. **Krilov, A. N., On some differential equations of technical physics [O nekim diferentsijalnim jednachinama tekhnichke fizike],** Belgrad, Izd. Pred. Narod. Repub. Srbije, 1952, 431 pp.

This is a reissue of Krylov's book written in 1931, and is edited by Klitchieff, et al. It contains eight chapters on the subject of differential equations. Chap. I deals with the applications of ordinary differential equations with constant coefficients, and analyzes vibration problems by the standard methods, i.e., Fourier analysis, etc. It contains an excellent treatment of the general problem of small vibrations from the Lagrangian point of view; in particular, that of Krylov's original method of obtaining the characteristic equation (nonalgebraic interpretation). Many examples are carefully worked, and the results are presented in tabular and graphical forms. Chap. II presents the elements of the theory and practice of linear partial differential equations, starting with the Euler-d'Alembert types and giving the transformations rendering the integration simple. The three-dimensional wave equation is dealt with in a very satisfactory manner.

Theorems are carefully stated and representations of solutions in integral and series form are given wherever feasible. Chaps. III and IV are devoted to the integrals and examples (in detail) of some of the equations treated in chap. II. In chap. V, the fundamentals of the complex variable theory and its application to differential equation are discussed. A clean exposition and some examples of the Hurwitz stability criteria are given. Chap. VI should be of interest to the applied mathematician and engineer, since the subject is the convergence and rates of convergence of Fourier series. The original ideas of Poincaré are presented here. Chap. VII treats in detail the explicit solutions of some of the boundary-value problems associated with the inhomogeneous wave equation and telegraphers equation. Several interesting physical examples are studied, and a great deal of attention is paid to the character of the solutions. Some useful numerical methods are expounded for the solution of problems related to the afore-mentioned types. Chap. VIII is an exposition of some methods for solving the Navier-Stokes equation in radial coordinates; the emphasis here is on elastic-isotropic solids. Special forms of solution are discussed, but briefly.

Reviewer finds the text to be written in good style and would welcome an English translation. It would serve as a suitable study and reference, particularly for the wealth of examples contained therein. There are few misprints, the type is easy to read, and the continuity of subject matter in order.

J. J. Brandstatter, USA

2404. Mohr, E., Construction of the generalized Green function (in German), *J. reine angew. Math.* **189,** 129–140, 1951.

2405. Mönnig, P., On the solution of the Hamilton-Jacobi differential equation by means of separation of variables (in German), *Math. Z.* **56,** 49–56, 1952.

2406. Müller, C., On the fundamental operations of vector analysis (in German), *Math. Ann.* **124,** 427–449, 1952.

In E_3, let G denote a regular region [Kellogg, "Potential theory," Springer, Berlin, 1929, p. 113], $|G|$ its volume, F its boundary, N the exterior normal to F, and da the element of area on F. If $P \in G$ and $G_n \subset G$, define $G_n \to P$ to mean that G_n lies in a small sphere with center at P if n is sufficiently large. [Although it is not explicitly demanded in this definition (p. 429), some proofs (cf. (1.8)) seem to require $P \in G_n$, and in the introduction the regions G_n "sich auf den Punkt P zusammenziehen."] If the expressions

$$\frac{1}{|G_n|}\int_{F_n} N_n \cdot V da_n \qquad \frac{1}{|G_n|}\int_{F_n} N_n \times V da_n$$

have limits as $G_n \to P$ that are independent of the sequence G_n, these limits are denoted respectively by div V and rot V. If the scalar $\phi \in C'$, the Laplacian is defined as $\Delta\phi \equiv$ div grad ϕ. (The similar definition of grad ϕ with integrand ϕN_n is not used. These definitions appear in several texts on vector analysis and theoretical physics. In his lectures, Gibbs used the above definition of div and a definition of rot suggested by Stokes' theorem [Gibbs and Wilson, "Vector analysis," 5th ed., Yale Univ. Press, 1925, pp. 187, 194]. No discussion known to the reviewer has used these definitions in a consequential way; the familiar expressions involving derivatives of the components, valid if $V \in C'$, have ordinarily been introduced at once and thenceforth used exclusively.) An example is given of a continuous V for which div V exists and is continuous although V is nondifferentiable on a dense set. The familiar integral identities hold provided the relevant div's and rot's are continuous, and if $\Delta\phi = 0$ in G, then ϕ can be expressed in the familiar way in terms of ϕ and grad ϕ on F.

It has been shown by Wintner [*Amer. J. Math.* **72,** 731–738, 1950] that there exists a scalar function ρ continuous on E_2 whose logarithmic potential ϕ fails to have ϕ_{xx}. It is shown here that if ρ is continuous (not necessarily Hölder continuous) in $G \subset E_3$ and ϕ is its Newtonian potential, then $\Delta\phi$ exists at all points of G and $\Delta\phi = -4\pi\rho$. Maxwell's equations are treated for fields periodic in time that are generated by electric and magnetic current densities with continuous divergences. Finally, the equations $\Delta\phi + \rho\phi = 0$ and $\Delta\phi + \lambda\rho^2\varphi = 0$ are discussed with ρ continuous.

Courtesy of Mathematical Reviews F. A. Ficken, USA

2407. Gavurin, M. K., On systems of differential equations of the form $y' = Ay^2 - 2By + C$ (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **84,** 205–208, 1952.

2408. Ladízhenskaya, O. A., Fourier's method for hyperbolic equations (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **74,** 417–420, 1950.

2409. Heinhold, J., Theory and applications of functions of complex variables [Theorie und Anwendung der Funktionen einer komplexen Veränderlichen. Ein Lehrbuch für Studierende der Naturwissenschaften und Technik. Ester Band], München, Leibniz Verlag, 1949, 213 pp. DM 15.

2410. El'sgol'ts, L. E., On approximate integration of differential equations with retarded argument (in Russian), *Prikl. Mat. Mekh.* **15,** 771–772, 1951.

Paper discusses the numerical integration of equations of the type $(dx(t)/dt) = f(t, x(t), x(t - \tau))$, where $x(t)$ is given as $\varphi(t)$ for $t_0 \leqq t \leqq t_0 + \tau$. Various methods are recommended, all of which combine the method of successive approximations for differential equations on certain subintervals with other numerical integration techniques.

Courtesy of Mathematical Reviews E. A. Coddington, USA

2411. Shura-Bura, M. R., Estimates of errors of numerical integration of ordinary differential equations (in Russian), *Prikl. Mat. Mekh.* **16,** 575–588, 1952.

Author obtains bounds for the error after n steps in the step-by-step numerical integration of $y' = f(x, y)$, first by the use of an extrapolatory quadrature formula, and second by an interpolatory quadrature formula. The results apply, as special cases, to Adams' method and to Milne's method. The derivation employs the roots of a characteristic equation associated with a certain difference equation. The method is extended to the case of systems of first-order equations.

Courtesy of Mathematical Reviews W. E. Milne, USA

2412. Paterson, S., The summation of a slowly convergent series, *Edinburgh Math. Notes* **38,** 5–7, 1952.

Formulas are obtained for estimating the value of $\Sigma_{n=1}^{\infty} n^{2r} e^{-n^2 x}$ when r is a positive integer and x is positive and near zero.

Courtesy of Mathematical Reviews R. P. Agnew, USA

2413. Germay, R. H., On the integration of iterative differential equations by the method of successive approximations (in French), *Bull. Soc. roy. Sci. Liège* **21,** 260–265, 1952.

Author considers a system of differential equations of the form

$$\frac{dy_n}{dx} = F_n(x, y_n, y_{n+1}) \quad (n = 1, 2, 3, \ldots)$$

where the typical function F_n is not given explicitly, but is defined as the limit of a sequence of functions $F_{n1}, F_{n2}, F_{n3}, \ldots$. Making appropriate assumptions concerning the boundedness and continuity of the functions $F_{n\mu}$, and using a modification of Picard's method of successive approximations, he proves the existence of a solution of the system of equations, satisfying a set of initial conditions of the form $y_n(x_0) = y_0 (n = 1, 2, 3, \ldots)$.

Courtesy of Mathematical Reviews L. A. MacColl, USA

2414. Brock, P., and Murray, F. J., The use of exponential sums in step by step integration. II, *Math. Tables Aids Comput.* **6,** 138–150, 1952.

[For part I, see title source, **6,** 63–78, 1952.] The error analysis for the exponential method is predicated on the convergence of the series expansion of an explicitly given function. The authors provide a table for computing the radius of convergence in cases of complex λ. Methods for accurate calculation of the coefficients in the open-type formulas are studied in detail. The paper closes with some practical problems to which the method of exponential sums has been successfully applied.

Courtesy of Mathematical Reviews W. E. Milne, USA

2415. **Nordon, J., New example for integration by quadrature of an interesting differential equation of first order. II** (in French), *C. R. Acad. Sci. Paris* **235**, 1181–1182, 1952.

[For part I, see AMR **4**, Rev. 2792.] Author determines certain functions $f(x)$ such that the equation $dy/dx = [f(x) - y^2]^{1/2}$ can be solved by quadratures.

Courtesy of Mathematical Reviews L. A. MacColl, USA

2416. **Pflanz, E., On the improvement of convergence of slowly convergent infinite series** (in German), *Arch. Math.* **3**, 24–30, 1952.

When a convergent series Σa_n has terms satisfying appropriate conditions, it is possible to calculate the terms of a new series Σb_n which converges more rapidly to the same value. Suppose, for example, $\Sigma a_n = s$ and

$$a_n/a_{n-1} = 1 - \alpha/n + \gamma_{n-1}/n$$

where $\alpha > 1$ and $\gamma_n \to 0$ as $n \to \infty$. One of the series treated is the series $\Sigma b_n'$ for which

$$b_0' = a_0\left[1 + \frac{\alpha}{\alpha - 1}\frac{a_1}{a_0 - a_\cdot}\right]$$

and

$$b_n' = a_n\left[1 + \frac{\alpha}{\alpha - 1}\left(\frac{a_{n+1}}{a_n - a_{n+1}} - \frac{a_{n-1}}{a_{n-1} - a_n}\right)\right]$$

when $n > 0$. For the case of the series $\Sigma a_n = \Sigma_{n=0}^{\infty}(n+1)^{-3/2}$, which converges to $2.6123753487\cdots$, $a_0 + \cdots + a_8 = 1.963713$ while $b_0' + \cdots + b_8' = 2.612674\cdots$. Iteration of this same procedure gives a new series $\Sigma b_n''$ for which

$$b_0'' + \ldots + b_7'' = 2.61237\cdots.$$

Other procedures, some appropriate for alternating series, and pertinent references are given.

Courtesy of Mathematical Reviews R. P. Agnew

2417. **Mirolyubov, A. A., Solution of differential-difference equations with linear coefficients** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **85**, 1209–1210, 1952.

The author states without proof a method for finding, by contour integration, a particular solution of the differential-difference equation $M[f(x)] = F(x)$, where

$$M[f(x)] = \sum_{p=0}^{n}\sum_{q=0}^{m}(a_{pq}\,x + b_{pq})\,f^{(p)}(x + h_q)$$

x here is complex along with the a_{pq}'s and b_{pq}'s; $a_{nm} \neq 0$ and $a_{n0} \neq 0$; $0 = h_0 < h_1 < \ldots < h_m$; $F(x)$ analytic in some region. Turning to the homogeneous equation $M[f(x)] = 0$, he shows that any analytic solution $f(x)$ holomorphic in the strip $q_2 < \mathrm{I_m}x < q_1$ may be written as the sum of two solutions analytic in the half-planes $\mathrm{I_m}x < q_1$ and $\mathrm{I_m}x > q_2$ respectively, the half-planes being slit in a certain way. He states growth and series representation theorems for $f_1(x)$ and $f_2(x)$. He makes use of (unavailable) results of Leont'ev [*Trudi Gor'kovsk. Gos. Ped. Inst. Fiz.-Mat. Fak.* **14**, 3, 1951].

Courtesy of Mathematical Reviews J. M. Danskin, USA

2418. **Donan, J. F., The serial-memory digital differential analyzer**, *Math. Tables Aids Comput.* **6**, 38, 102–112, Apr. 1952.

Paper presents a brief explanation of the logical embodiment of digital differential analyzers and a description of some of the machines most recently designed. The author points out the compactness, simplicity of construction, and digital accuracy that are obtainable with a serial-memory digital differential analyzer. An interesting description is given of the basic sections of such an analyzer: The control unit, the memory, the computing center, and the power supply. The author also mentions a new analyzer that operates on the decimal rather than the binary system. J. Aronofsky, USA

2419. **Hammersley, J. M., Lagrangian integration coefficients for distance functions taken over right circular cylinders**, *J. Math. Phys.* **31**, 139–150, 1952.

2420. **Blanch, G., On the numerical solution of equations involving differential operators with constant coefficients**, *Math. Tables Aids Comput.* **6**, 219–223, 1952.

The equations to which the method of the paper applies are of the form

$$Ly = F(y, x) \qquad [1]$$

where L denotes a linear differential operator. The procedure is to set up the integral equation for [1] by the method of variation of parameters, just as though the right-hand member were independent of y. The integral is then evaluated by some suitable quadrature formula using the equally spaced ordinates y_n, y_{n-1}, $\ldots$, y_{n-k}. Of these, $y_{n-1}, \ldots, y_{n-k}$ are known from previous steps and it turns out (this is the crux of the paper) that the coefficient of the term $F(y_n, x_n)$ vanishes, so that the integral can be evaluated without previous knowledge of y_n. Thus a value of y_n is obtained by simple quadratures and the computation proceeds step by step.

Courtesy of Mathematical Reviews W. E. Milne, USA

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 2476, 2517, 2593)

2421. **Bereis, R., Position of the pole at infinity in plane motion** (in German), *Öst. Ing.-Arch.* **6**, 3, 246–255, May 1952.

Author extends his earlier paper [AMR **4**, Rev. 4376] on the kinematics of a system in plane motion to the case in which the instantaneous center (pole) of the system is at infinity. By the use of complex representation he examines the geometric relations pertaining to the position vector and its derivatives, up to the fifth order, of a point of the moving system. The existence of certain quasi-poles and the degeneration and simplification of the curves associated with the point paths are demonstrated, and the results are applied to two types of slider-crank mechanisms.

G. A. Nothmann, USA

2422. **Meshcherskiĭ, I. V., Collection of problems on theoretical mechanics [Sbornik zadach po teoreticheskoĭ mekhanike]**, Moscow-Leningrad, Gosud. Izd. Tekh.-Teor. Lit., 1950, 384 pp.

This collection of concrete, down-to-earth examples, many of them numerical, with answers given, could accompany an undergraduate text for engineering students. No exposition of theory is included, but problems are graded according to difficulty and organized as to topics. Chapter headings are: I. Plane systems of force; II. Spatial systems of force; III. Motion of a point; IV. Simple motions of a rigid body; V. Composition and resolution of the motions of a point; VI. Plane motions of a rigid body; VII. Rotation of a rigid body about a stationary point; VIII. Dynamics of a particle; IX. Dynamics of material systems; X. Theory of vibrations. Chapter IX concludes with a section on the Lagrange equations.

A. S. Householder, USA

2423. Dedecker, P., Influence of Coriolis forces on the motion of the atmosphere (in French), *Acad. roy. Belgique, Bull. Cl. Sci.* (5) **38**, 6, 637–641, 1952.

Article gives a formal demonstration from first principles that a cyclonic vortex is subject to a northward force and an anticyclonic vortex to a southward force, an effect discussed by Rossby. The author brings into prominence the vertical component of the Coriolis force, and stresses the fact that this is usually ignored. However, to obtain practical results from mathematical meteorology, some approximations are essential, and to include these small terms is a council of perfection. The author's treatment is easily interpreted only on a spherical earth, implying an approximation more serious than that which the author criticizes. J. S. Sawyer, England

2424. Bautin, N. N., A dynamical model of a chronometric movement (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **12**, 3–22, 1952.

A simplified model of a complicated clock mechanism is given, consisting of a mass attached to a spring in rectilinear motion and undergoing impulses from a moving infinite band from which protrude teeth at equally spaced intervals. The motion is reduced to the solution of four linear differential equations with a discontinuity. The solutions are in terms of two parameters ξ, η which undergo a linear transformation S. The fixed points of S correspond to the periodic motions of the initial mechanism, and their stability is discussed. [References: Andronov and Neimark, *Doklady* **51**, 1, 1945; Bautin, *Doklady* **61**, 1, 1948; Bautin, AMR **3**, Revs. 423, 2176.] S. Lefschetz, USA

2425. Stumpff, K., Simple symmetrical derivation of particular Lagrange solutions of the three-body problem (in German), *Astr. Nachr.* **280**, 91–93, 1951.

2426. Baker, H. D., Claypoole, W., and Fuller, D. D., Further developments in the measurement of the coefficient of static friction, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 23–29, 1952.

Main purpose of these tests is to determine the effect of mechanical disturbances on the static coefficient of friction of surfaces lubricated with ricinoleic and malonic acids. Previous tests of bodies not insulated from vibrational disturbances indicated that the static coefficient of friction tended to vanish when the surfaces were lubricated with these acids. After carefully insulating the body from external vibrational effects, using a Julian-type suspension system, the authors found that the coefficient did not tend to vanish, but remained in the order of 0.10 to 0.14. G. N. Cox, USA

2427. Limiting loading capacities of spur gears and helical gears [Belastungsgrenzen bei gerad- und schrägverzahnten Stirnrädern], Braunschweig, Friedr. Vieweg & Sohn; Schriftenreihe Antreibstech., H. 5, 132 pp. DM 16.80.

Helical and straight spur gears are calculated with consideration of the following factors: (a) Hydrodynamic capacity based on oil-film thickness; (b) Hertz's surface pressure; (c) flexural strength of the gear teeth; (d) loss of efficiency in heat dissipation; (e) local heat increase along the contact line (the viscosity is assumed to be constant). The influence of each of these five items on the pressure angle, the tooth depth, the helix angle, the diametral pitch, and the length of contact line is analyzed for low and high speed of operation.

Formulas for calculation are derived and discussed; figures and diagrams are presented for elucidation of procedure.

The reports have been prepared and research has been carried out at the Technische Hochschule in Braunschweig, and later in München, with a rigorous theoretical and experimental accuracy. W. Ornstein, USA

2428. Hain, K., Applied gear theory [Angewandte Getriebelehre], Hannover, Darmstadt, Hermann Schroeder Verlag, 1952, 408 pp., 491 figs. DM 24.

This is the best reference, known to the reviewer, in the field of linkage design. It presents, in an admirably concise form, much material previously available only from scattered sources.

In the first one third of the book the author presents the basic material of kinematic analysis, including types of joints, conditions for constraint, types of motion, curvature relations for point paths, inflection and cuspidal circles, velocity and acceleration analysis. The treatment is brief but well covered by references for those who wish more detail. The treatment is limited to plane motion.

The remainder of the book deals with modern methods of kinematic synthesis based primarily on German developments. The treatment is brief. References are given to original papers listed in the extensive bibliography. Material is organized into chapters as indicated below.

"Kurvengetriebe" contains a discussion of the advantages and disadvantages of cam-type versus linkage mechanisms, and some design problems for cam-type mechanisms. Author has left a more detailed treatment of cams to other sources.

"Kurbelgetriebe" deals primarily with gross motions of 4-bar linkage and slider crank and shows a number of approximate and exact "straight-line" mechanisms.

"Mittelbare Getriebsynthese" considers primarily the type of design problem which might be solved using atlases of coupler curves and b-curves (curves showing relationship between two adjacent angles in a 4-bar linkage). Usefulness of such atlases is pointed out.

"Getriebsynthese mit Hilfe von Ersatzgetriebe." Basic idea here is that, if a cam-type mechanism is first designed, it can be replaced by a linkage including a 4-bar generating a coupler curve approximately congruent to the "substitute" cam curve. Important applications to various 6-bar linkages are shown.

"Mass-synthese." This might be called the classical material of size synthesis, dealing with problems for which exact solutions are possible, involving correlated point positions, angles, and velocities in plane systems. For example, one problem shows the design of a 4-bar linkage for three specified positions of a coupler joint, two specified angles for one crank, and one specified angle for the other crank. Importance of carefully formulating problem statements is emphasized.

"Mass-synthetische Kurven" discusses important curves useful in synthesis, including circle-point curves, center-point curves, cubics of stationary curvature (here called Kreisungpunkt- and Angelpunktkurven), the R_1, R_m, and s_1 curves, the ρ_1, ρ_m, and q curves, and the C_1 curve (containing points of a moving plane system having six positions on a conic). Author emphasizes importance of special cases for which these curves have simplified forms.

"Punktlagenreduktionon" explains, with several excellent illustrations, the powerful (and relatively new) point-position-reduction technique. One of the simpler problems discussed is that of designing a 4-bar linkage so that a coupler point will pass through five specified positions. This is reduced to the elementary problem of passing a circle through three points. Also shown are applications to problems of correlating point positions with crank angles, and designing of four- and six-bar computing linkages.

"Symmetrielagen als Hilfsmittel für gesteigerte Anspruche"

explains more fully the possible uses of symmetry in extending the number of exact points of correspondence between desired and attained motion. It is shown, for example, that it is possible to design a 10-bar linkage with a rest period theoretically exact at 29 points.

The author completed his manuscript in 1947 but has included an appendix to the bibliography through 1950.

A. S. Hall, USA

2429. **Litvin, F. L., Determination of tooth thickness of worm and helical gears by means of rollers and balls** (in Russian), *Trudi Sem. teor. Mash. Mekh.* **10**, 39, 22–55, 1951.

The necessary accuracy of tolerance control for spatial gears makes direct measurements of tooth thickness w_{oc} impracticable. A method using cylindrical rollers or balls inserted between the teeth is proposed. A (parametric) relation between the position parameter r of the ball or roller and w_{oc} is developed, but the equations are too involved for practical use. Therefore, approximate formulas for the relation between dr and dw_{oc} are derived, which make it possible to estimate the relation of the error to the tolerance. Numerical examples are given for the three cases of evolute, convolute, and Archimedean tooth surfaces.

A. W. Wundheiler, USA

2430. **Budíka, Yu. N., Meshing theory and the relative wear resistance of plane engagements of general type** (in Russian), *Trudi Sem. teor. Mash. Mekh.* **10**, 39, 56–74, 1952.

The problem is to design open (nonlubricated) plane gearings with less than the conventional wear of cycloidal teeth. The author first determines the normal reaction between any two conjugate profiles (it is proportional to $(\sin 2\alpha_0)^{-1/2}$ where α_0 is the meshing angle). Since $\alpha_0 \neq 45°$ (for reasons of undercutting), the author proposes to minimize wear by minimizing the specific work ξ of friction, and finds that ξ is not a minimum for cycloidal gearing. Some design aspects are discussed, and a continuation of the paper announced.

A. W. Wundheiler, USA

2431. **Chetaev, N. G., On the choice of parameters of a stable mechanical system** (in Russian), *Prikl. Mat. Mekh.* **15**, 3, 371–372, May–June 1951.

A system of linear differential equations

$$dx_s/dt = \sum_r p_{sr}x_r \qquad (s, r = 1, \ldots, n) \qquad [*]$$

is considered, where the p_{sr} are constants depending on certain parameters. Under certain assumptions on these parameters, an upper bound for the time of travel of a point $(x_1, \ldots, x_n)$ on a trajectory of [*] from the sphere $x_1^2 + \ldots + x_n^2 = A$ to the sphere $x_1^2 + \ldots + x_n^2 = \epsilon$ is obtained. A condition on the parameters is given for which this upper bound is a minimum.

Courtesy of Mathematical Reviews E. A. Coddington, USA

Gyroscopics, Governors, Servos

(See also Revs. 2428, 2602)

2432. **Marcy, H. T., and Yachter, M., Steady-state systems engineering in automatic process control,** "Automatic and manual control," New York, Academic Press, 159–167, 1952. $10.

Authors contend that, in process control, steady-state reponse is more important than dynamic response. System equations relating increments in dependent and independent variables are linear algebraic equations for steady-state conditions. Effects of errors in monitoring sensing devices may be treated as changes in independent variables. Expression for mean-square error in any dependent variable is obtained in terms of mean-square errors of monitoring sensing devices and independent variables. Value of this type of analysis is that it tells where monitoring and control action should be introduced to give tight control of given dependent variables.

A. A. Schy, USA

2433. **Vazsonyi, A., Transient analysis of servo-mechanisms,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 161–166, 1952.

It is shown that coefficients in the characteristic equation of a third- or fourth-order system can be "optimized" without finding the roots of that equation, optimum being defined by given problem. Theory is applied to several cases of interest. There are many misprints.

C. M. Ablow, USA

2434. **Dini, G. E., Some considerations on the aerodynamic servocontrol of the helicopter** (in Italian), *Aerotecnica* **32**, 2, 63–66, Apr. 1952.

Author develops equations for the first five Fourier series coefficients of the pitching angle of rigid helicopter rotor blade, which can be rotated about its longitudinal axis by means of special control surfaces (D'Ascanio and Hiller rotors). The rotor is supposed to be in uniform translatory motion and rotation about its axis. Moments due to centrifugal forces, to weight, and to angular accelerations of the blade about its pitching and flapping axes are considered in detail. The influence of some section characteristics on control forces of the blade during its rotation about the rotor axis and on blade motion is discussed briefly. Paper is intended as preliminary for a rational calculation of servocontrol surfaces.

A. Kuhelj, Yugoslavia

2435. **Chu, Y., and Gould, L. A., Analogies for hydraulic and e'ectric drives in servomechanisms,** Ann. Meet. ASME, New York, Dec. 1952. Paper 52—A-101, 17 pp., 24 figs.

A collection of the analogous basic equations of response of d-c electric and of hydraulic-powered servomechanisms. The compounded Ward-Leonard electric drive is described, and it is shown that a hydraulic transmission (variable displacement pump driving constant displacement motor) may be made to have a similar type of response by feeding back a signal of line pressure to the input of the controller of the variable displacement pump.

R. M. Stewart, USA

Vibrations, Balancing

2436. **Lo, H., A nonlinear problem in the bending vibration of a rotating beam,** *J. appl. Mech.* **19**, 4, 461–464, Dec. 1952.

Paper presents solution for vibration of rotating beam in which plane of vibration makes an angle of $(\pi/2) - \beta$ with plane of rotation. It extends an earlier work by Lo and Renbarger to include Coriolis acceleration term which renders equation of motion nonlinear. Problem is simplified and reduced to single degree of freedom by considering the beam to be rigid in bending, but elastically supported at its root.

Denoting by $W(x)$ the displacement in the plane of vibration at any point x on beam, vector velocity and acceleration equations are written. Equation of motion follows from Newton's law. In dimensionless form, equation is

$$\overline{W}'' + \overline{W}\,\overline{W}' + \overline{W} = 0$$

In the phase plane, corresponding equation is integrable, giving velocity as function of displacement. Depending upon initial coordinates, motion may be stable and periodic, or it may

be unstable. Solutions for stable case are carried out for various values of a dimensionless amplitude parameter and compared with those in which the Coriolis term was neglected. The error is plotted against amplitude parameter. Author states that the Coriolis term may be neglected in existing practical applications. W. C. Hurty, USA

2437. Weidenhammer, F., Nonlinear bending vibrations of a rod with axially pulsating load (in German), *Ing.-Arch.* **20**, 5, 315–330, 1952.

Paper deals with the lateral vibratory motion of a bar, simply supported at its two ends and subjected to an axial compressive force of sinusoidally varying amount. The linearized theory leads to a Mathieu differential equation for the time-dependent factor in the function describing the lateral motion. In the unstable regions of the parameter plane for the Mathieu equation, the linearized theory is unable to predict any details of the motion. Author extends the differential equation of motion by including appropriate nonlinear terms (as one does, e.g., for describing the postbuckling behavior of columns). The Ritz procedure allows separation of variables. If one limits attention to sufficiently small driving frequencies, a cubic term appears in Mathieu's differential equation. This "nonlinear Mathieu differential equation" is solved by a perturbation procedure; the coefficient of the harmonically varying term serves as the parameter in the expansions involved. There are various types of solutions, corresponding to the solutions of Mathieu's linear equation (ce_1, se_1, ce_2, se_2, etc.). The stability of the solutions is investigated in the customary way by setting up a differential equation for a "variational" quantity. This differential equation is here of Hill's type and reduces for certain classes of the motion again to a Mathieu equation. The motions now prove to be stable.

K. Klotter, USA

2438. Bleich, F., McCullough, C. B., Rosecrans, R., Vincent, G. S., The mathematical theory of vibration in suspension bridges, Washington, D. C., Dept. Comm., Bur. Publ. Roads, 1950, 429 pp. $1.25.

The collapse of the Tacoma Narrows Bridge in 1940 as a result of heavy vibrations due to wind action gave rise to the organization of the Advisory Board on the Investigation of Suspension Bridges, under the supervision of which comprehensive investigations on the dynamic stability and the causes underlying the phenomenon of vibration of suspension bridges were to be carried out. The present book constitutes a detailed report on the work and investigations hitherto done. More concisely the book has the following content: Chap. 1, Introduction, history; Chap. 2, Statement of problem and suggestion of a program of investigation together with a determination of physical data needed for solution of the problem; Chap. 3, Free vibrations of a suspension bridge. Exact solution of the differential equation as well as an approximate solution based upon the energy method is developed. From this the influence of various design factors such as dead load, sag-span ratio, flexural rigidity of stiffening frame, etc., is examined; Chap. 4, Influence of continuity of the stiffening trusses; Chap. 5, Torsional vibrations are studied by means of the energy method, effect of flexural and torsional rigidity of towers. Longitudinal diagonal stays connecting top of tower with the floor in plane of the cables, referred to as "tower stays," are introduced and their influence is studied; Chap. 6, Structural damping; Chap. 7, The flutter theory. Theodorsen's theory of the flutter of a flat plate in a steady wind stream is modified to fit the problem at hand; Chap. 8, Linearized deflection theory. Theory developed to be applied to suspension bridges with tower stays; Chap. 9, Experimental verification of the linearized deflection theory; Appendixes A–H, where additional information on the afore-mentioned items is given.

The reviewer finds chapters 5, 6, and 7 to be the most interesting ones, and especially the application of Theodorsen's flutter theory means a fine step in the direction of finding a solution to the problem suitable for practical application. On the other hand, the reviewer misses the information that the simplifications made in the linearized theory are the same as usually made in the theory of influence lines of suspension bridges. It is also to be noted that too few European authors have been listed in the bibliography. This book, however, represents a fine contribution, and the reviewer thinks that it should be possessed by most engineers associated with the profession.

L. N. Persen, Norway

2439. Carter, B. C., Torsional vibration in aircraft power plants: Methods of calculation, *Aero. Res. Counc. Lond. Rep. Mem.* 2739, 63 pp., 1937, published 1952.

The report is in three parts. A brief introduction followed by a general treatment and the application of the method to a typical twelve-cylinder Vee engine make it useful to aircraft and power-plant designers.

The author points out correctly that the "minor" criticals can be, in some cases, as important as the "major" criticals. The engine crankshaft together with the propeller is considered as a flywheel system, which makes the problem much easier. But the results should be used cautiously, as fatigue failures due to propeller blade vibrations may also occur.

The third part, which presents a typical calculation for a twelve-cylinder Vee engine for both single-node and two-node vibration is, in reviewer's opinion, most useful from the viewpoint of the designer, who is interested in applying a general method to a particular case. The airscrew is assumed rigid, but reviewer feels that this is not a serious handicap of the method.

While the report deserves the close attention of aircraft power-plant designers, it is a pity that, although the original report was ready by 1938, it was not published until 1952. It would have been more useful if the author had brought the report up to date and referred to work done in this field during and after World War II. Y. V. G. Acharya, Holland

2440. Vekua, I. N., On the proof of some uniqueness theorems occurring in the theory of steady vibrations (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **80**, 341–343, 1951.

V. D. Kupradze [see, e.g., "Boundary problems of the theory of vibrations and integral equations," Gostehizdat, Moscow-Leningrad, 1950], by using a certain positive definite form called the quasi-energy, has shown the uniqueness of the solution of certain boundary-value problems in electromagnetic and elastic vibrations. The present paper contains a simple proof of the uniqueness theorem in the case of three-dimensional elasticity, using the same method used earlier to prove uniqueness in the electromagnetic case [I. N. Vekua, *Trudy Tbliss. Mat. Inst.* 12, 105–174, 1943]. The boundary condition at infinity is taken to be only

$$\frac{\partial U^{(j)}}{\partial R} - ik_j U^{(j)} = o(R^{-1}), \; j = 1, 2$$

whereas Kupradze requires, in addition, that $U^{(j)} = O(R^{-1})$, $j = 1, 2$, which is shown to be implied by the first condition (here the displacement vector $U = U^{(1)} + U^{(2)}$, with rot $U^{(1)} = 0$ and div $U^{(2)} = 0$).

Courtesy of Mathematical Reviews J. B. Diaz, USA

2441. **Eringen, A. C., On the non-linear vibration of circular membrane,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 139–145, 1952.

Two nonlinear partial-differential equations are obtained for the rotationally symmetric vibrations of circular membranes. Radial deformation and transverse deflection are not assumed to be small, contrary to the classical theory. Thus the effect of the additional membrane stresses developed during the vibration are not neglected. The differential equations are solved by use of the perturbation procedure for the case of free vibration. The radial slope and the tangential membrane strain at any point are obtained for a given initial deflection of a Bessel-function type and for an initial stress. The classical theory is found to be a limiting case of the present theory.

From author's summary by W. M. Whyburn, USA

2442. **Diaz, J. B., On the estimation of torsional rigidity and other physical quantities,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 259–263, 1952.

Detailed development of a variational method for obtaining upper and lower bounds for torsional stiffness. Method does not differ essentially from the well-known Ritz and Trefftz procedure [Proc. sec. inter. Cong. appl. Mech., Zurich, 1927, pp. 131–137]. Results are indicated for a hollow square section.

S. H. Crandall, USA

2443. **Okumara, A., and Ikai, S., On some approximate formulas for the frequencies of a rod in lateral vibration under axial force** (in Japanese), *Trans. Soc. mech. Engrs. Japan* **17,** 57, 8–13, Apr. 1951.

Paper discusses the lateral vibration of a uniform rod under an axial force and presents formulas to determine natural frequencies for all possible combinations of the following boundary conditions at both ends: $y = 0$ and $y'' = 0$; $y = 0$ and $y' = 0$; $y' = 0$ and $y''' = 0$; $y'' = 0$ and $y''' - \alpha y' = 0$, where y represents the lateral displacement and α the normalized axial force. Formulas for the first, second, and third modes are shown in a table.

S. Fujii, Japan

2444. **Golomb, M., and Rosenberg, R. M., Critical speeds of uniform shafts under axial torque,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 103–110, 1952.

Authors give a mathematical analysis of reduction in critical speed or lateral natural frequency of uniform round shaft due to torque. Analysis is for fixed and simple ends (rigid and self-aligning bearings). Solution is given in nondimensional form in explicit equations and plotted as curves of reduced torque vs. reduced frequency. Solution is involved and in some places redundant, but illustrates a clever application of symmetric functions. Reviewer notes that the linear relationship between load and frequency squared [Lurie, AMR **5,** Rev. 3031] does not obtain; for large torques, the relationship is approximately linear between torque and frequency to the fourth power for the first mode.

R. Plunkett, USA

2445. **Young, D., Theory of dynamic vibration absorbers for beams,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 91–96, 1952.

Paper gives sketch of theory, but the case selected is not suited for reaching important conclusions, essentially extending the well-known elementary results [J. P. den Hartog, "Mechanical vibrations"]. Approximate solution presented is unsatisfactory (except when absorber is tuned to fundamental) because author fails to retain *whole* set of "lower" modes in simplified analysis in cases when absorber is tuned to overtone.

J. H. Greidanus, Holland

2446. **Levy, S., and Kroll, Wilhelmina D., Errors introduced by finite space and time increments in dynamic response computation,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 1–8, 1952.

Paper shows that, for the uniform beam dynamical problems under consideration, responses to an impact for 5-mass and 7-mass idealizations of the beam are approximately the same. It is concluded that 5-mass points are adequate in such problems.

Effect of varying time increments is investigated in the case of simple single-degree-of-freedom oscillator using two finite difference approximations. The ordinary approximation, entailing evaluation of derivative at middle ordinate, is shown to diverge for too large values of Δt. Solutions with "Houbolt cubical approximation," with derivative evaluated at an end point, are shown to be convergent for all Δt, even though limiting solutions may be grossly in error. It is concluded that this characteristic of the Houbolt method renders it a superior approximation technique.

In opinion of reviewer, the contrary is true. An approximation which, if it converges at all, does so with tolerable error, and which sounds a warning by diverging when Δt is too large, is to be preferred.

L. Becker, USA

2447. **Chaplin, R., The natural frequencies of vibration of prismatic blades with particular reference to a 12-stage turbine,** *Aero. Res. Counc. Lond. curr. Pap.* 95, 15 pp., 10 figs., 1952.

A theoretical development following classical lines is given for the flexural and torsional vibrations of prismatic beams. The effects of shear deflection and rotary inertia are included in flexure, and consideration of root stiffness is given for the torsional vibration.

Comparison of computed results with experimental observations on a 12-stage, 3000-rpm turbine, indicates reasonable agreement up to measured frequencies of 5000 cps, if the effects of manufacturing tolerances in constructing the blades and small differences in chemical composition of blade material from the ideal are considered.

J. B. Duke, USA

2448. **Schmidt, G., Coupling of horizontal vibrations of frame foundations** (in German), *Bauingenieur* **27,** 12, 437–440, Dec. 1952.

The problem considered is the determination of the natural frequencies of horizontal vibration of a rigid-frame turbine foundation supported on a heavy base slab. The structure is idealized in the following manner. The base slab is treated as a rigid body on an elastic foundation. The horizontal member of the frame is considered to be a second rigid mass and the two vertical legs are assumed to serve as massless beam springs. Considering horizontal displacements of the two masses and rotation of the base, the assumed system has three degrees of freedom in a plane.

The equations of motion for the idealized system are formulated and solved using conventional procedures. A numerical example is worked out in detail. It is shown that the frequencies obtained may vary considerably from that which would be found if the displacement and rotation of the base slab are neglected.

D. Young, USA

2449. **Stückler, B., On the differential equations for the motion of an idealized automobile** (in German), *Ing.-Arch.* **20,** 5, 337–356, 1952.

Paper deals with the problem from a theoretical standpoint.

Sliding is disregarded, and vehicle is assumed to be a rigid-bodies system with nine coordinates. Actual formulation starts with virtual displacements theorem and d'Alembert's principle. Mathematical development follows, using Euler's equations and energy law. Formulas are applied to a numerical example from which stability considerations are derived. Reviewer notes these interesting conclusions: Solved differential equation shows that instability is present when traction is over back wheels; and that "mathematical" instability decreases with a greater, constant speed. Author closes with mathematical considerations of force-free movements. Reviewer points out the mathematical character of the paper, its rigor and soundness. It may contribute to improvement in dynamical characteristics of automobiles. J. E. Carrizo Rueda, Argentina

2450. Newmark, N. M., and Veletsos, A. S., A simple approximation for the natural frequencies of partly restrained bars, *J. appl. Mech.* **19,** 4, p. 563, Dec. 1952.

Paper gives a simple approximation for the natural frequencies of flexural vibration of a bar of constant mass per unit of length m, of constant flexural rigidity of cross section EI, and of span length L between supports which are nondeflecting but which offer a linear resistance to end rotations of the bar.

The approximate equations are similar to those given in a paper by N. M. Newmark relating to buckling loads for partly restrained bars [see AMR **2,** Rev. 455]. From authors' summary

Wave Motion, Impact

(See also Revs. 2658, 2662)

2451. Jardetzky, W. S., and Press, F., Rayleigh-wave coupling to atmospheric compression waves, *Bull. seism. Soc. Amer.* **42,** 2, 135–144, Apr. 1952.

The theory of dispersive Rayleigh waves coupled to atmospheric compressional waves is derived for the case of a solid surface layer. Numerical computation of phase and group velocity curves indicates that an additional branch may be introduced to the dispersion curves as a result of air coupling. Amplitudes of waves propagated according to the various branches are briefly discussed. From authors' summary by J. T. Wilson, USA

2452. Wood, D. S., On longitudinal plane waves of elastic-plastic strain in solids, *J. appl. Mech.* **19,** 4, 521–525, Dec. 1952.

Author applies theoretical methods used by von Kármán for longitudinal waves in bars, with suitable modifications for waves of large lateral extent. Relation between longitudinal stress and strain in present case is obtained from tensile test data by means of a plasticity theory which assumes no permanent volume change, Mises-Hencky yield condition (octahedral shear stress), and isotropic work-hardening. Results are illustrated by computations of propagation velocities in 24S-T aluminum alloy, and of propagation of a pressure pulse through a flat plate. Importance of hydrostatic compressibility in determining nature of waves is brought out.

Effects of pressure dependence of compressibility, temperature changes during compression, and time and rate dependence of mechanical properties are discussed qualitatively.

L. Malvern, USA

2453. Sretenskiĭ, L. N., On a method of determination of waves of finite amplitude (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 5, 688–698, May 1952.

Author reconsiders the method of Stokes for waves of finite height on deep water, since some of Stokes' work on the problem is not very clear. The coordinates x and y are expanded in terms of the velocity potential and the stream function. Stokes' results—as regards the form of the wave profile, the drift at the free surface, and speed of propagation—are obtained, but to a higher order of accuracy. It is not proved that the infinite series involved actually converges, but author states that the question of convergence can be settled by making use of some work by A. J. Nekrasov for which he received the Stalin prize.

J. K. Lunde, Norway

2454. Richter, H., Shock waves in isotropic elastic media (in German and French), Kongr. Thermodyn., Oct. 29–30, 1951, Lab. Rech. Tech. Saint-Louis, 263–279.

A study is made of the transmission of a supersonic shock wave into a stress-free isotropic solid. An equation of state defines the stress for finite deformation and finite change of entropy. The usual assumptions for acoustic waves of low stress level are replaced by a generalization of Hooke's law which, in the linear approximation, depends on four constants including entropy and, in the quadratic approximation, adds seven additional constants.

A criterion is given for stability of flow of a compressional wave. Expressions are also given for the excess of the speed of the stable shock wave over the speed of the acoustic wave in terms of density ratio, and for the entropy change in terms of stagnation pressure, absolute temperature, and density change. It develops that the excess of the speed of the shock wave must be small, as shown in some British experiments with lead and steel [D. C. Pack, et al., AMR **1,** Rev. 563].

The shear wave is also treated in the paper.

W. H. Hoppmann, II, USA

2455. Nagamune, T., On the travel time and the dispersion of surface waves. I, *Geophys. Mag., Tokyo* **24,** 1, 15–22, Aug. 1952.

The velocities of propagation of the surface waves depend on the crustal structure of the earth's surface, and vary with its periods and the thickness of layers. Author investigates the travel time of those surface waves which originated in the following three regions: (1) Eurasian continent; (2) north-west coastal region of the Pacific Ocean (Kurile, Kamchatka, Aleutian and Alaska region); and (3) the Pacific Ocean. The period of observation was three years. From author's summary

2456. Sretenskiĭ, L. H., Propagation of waves from a sounding disk (in Russian), *Uchen. Zap. mosk. Univ.* **154,** *Mekhanika* **4,** 275–285, 1951.

2457. Zelkin, E. G., Waves in a pyramidal horn (in Russian), *Zh. tekh. Fiz.* **21,** 10, 1228–1239, Oct. 1951.

Though the pyramidal horn is used extensively, the author has not found any reference in the scientific literature to the theory of the propagation of electromagnetic waves inside such a horn. A theory has been investigated by E. N. Maizel for a pyramidal horn of small aperture and a single type of wave (H_{01}) by making slight changes in the form of the walls; i.e., considering the walls of the horn as approximating to two opposing cones so that the surface can be expressed in terms of a spherical system of coordinates. A fuller investigation of this work for more general types of waves is given in this paper. Marie Goyer, England

2458. Craya, A., The criterion for the possibility of roll-wave formation, "Gravity waves," *Nat. Bur. Stands. Circ.* 521, 141–151, 1952. $1.75.

Roll waves occur in open channels in a transition region between the usual flow and one entraining air. Proceeding from

equations of Saint Venant, author makes a theoretical analysis for a prismatic channel of arbitrary cross section and general resistance laws. Two lines of approach are followed: (1) Investigation of the quasi-steady regime using a combination of surges and hydraulic jumps; and (2) consideration of the stability of an elementary wave. Both lead to criterion that roll waves are possible only when the celerity of Seddon is greater than the Lagrangian celerity for an elementary wave under the action of gravity and inertia. W. DeLapp, USA

Elasticity Theory

(See also Revs. 2451, 2638)

2459. **Heller, S. R., Jr., The stresses around a small opening in a beam subjected to bending with shear,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 239–245, 1952.

Paper states formulas and gives graphs for tangential stresses at the edge of "ovaloid" holes in the web of a beam in bending and shear. Work is a development of that of Joseph and Brock [AMR **4**, Rev. 1482] and uses the complex variable methods of Mushkelishvili. W. S. Hemp, England

2460. **Bijlaard, P. P., Determination of the effective width of plates with small deviations from flatness by the method of split rigidities,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 357–362, 1952.

This is another beautiful application of the author's method of split rigidities. Some results known previously by involved analyses are now derived in a very simple manner. Simple formulas are obtained for the effective width of a plate with initial curvature. Y. C. Fung, USA

2461. **Ivanov, N. I., Collection of problems on strength of materials [Sbornik zadach po soprotivleniyu materialov],** Moscow-Leningrad, 1951, 280 pp.

A standard collection of study problems for a traditional first course in strength of materials at the college level, in its 11th edition in 1951. It is interesting to note that there are no indications of recognition of nonelastic stresses and strains, plastic or ultimate design, etc. This seems odd in view of the fact that, from such information as is available, Russian design specifications for steel and for reinforced-concrete structures seem to be extensively based on plastic theory. G. Winter, USA

2462. **Weiss, O., Practical problems of statics of structures and their solution by the method of influence lines [Praktische Probleme der Baustatik und ihre Lösungen nach dem Einflusslinienverfahren],** Wien, Franz Deuticke, 1952, xi + 193 pp. $6.

Title implies a much wider conception of structural problems than those dealt with. Book presents a new method for finding stresses in framed structures and continuous beams by extensive use of influence lines. Author attempts to devise a method with the same mathematical simplicity as the Cross method of moment distribution, but without iteration, giving the relationship between external and internal forces in a very simple and, at the same time, precise form. He thinks that influence lines are the best means to achieve this simplification.

His development is based on the following material from German technical literature: (1) The theory of degree of fixity by Saliger; (2) the principle of transmission of deformation ("Prinzip der fortgeleiteten Verformung," by Kloucek); (3) four moment equations by Saliger, as well as Maxwell's principle of reciprocal deformations. He arrives at rather complicated equations for the influence lines for moments at joints of any framed structure. To facilitate the use of these equations and the determination of their constants, the book contains numerous tables and examples.

Reviewer believes that the use of influence lines for continuous frames and beams, as given in "Continuous frames" by Cross and Morgan, is no less efficient, but is simpler and more general in application than that given by author. This is not an easily read book, even presupposing the knowledge of other literature published in German periodicals. Practicing engineers, even those with a working knowledge of framed structure analysis, may find it difficult to apply this method.

J. B. Gabrys, USA

2463. **Gent, A. N., and Rivlin, R. S., Experiments on the mechanics of rubber. III: Small torsions of stretched prisms,** *Proc. phys. Soc. Lond.* (*B*) **65,** part 8, 392B, 645–648, Aug. 1952.

Paper provides experimental verification of theory relating torsion modulus of a rod, held at a fixed simple extension, to the extension ratio and extending force. Theory is applicable to small torsions of incompressible highly elastic material. Case of rods of circular cross section was previously dealt with by Rivlin and Saunders [AMR **4**, Rev. 3490]. The theory, generalized by Green and Shields to include uniform rods of any cross section [AMR **5**, Rev. 1015], is here verified for natural rubber rods of rectangular cross section. Range of side length ratios from one to four were tested, giving good agreement with theory in all cases. Appendix discusses relation between the experimentally determined couple and the (slightly different) couple term in the equations. D. G. Ivey, Canada

2464. **Arzhanikh, I. S., Integral equations of the dynamics of an elastic body** (in Russian), *Dokladi Akad. Nauk SSSR* (*N.S.*) **76,** 4, 501–503, Feb. 1951.

Consider the problem of finding integral equations satisfied by the displacement u of a three-dimensional isotropic elastic body, which satisfied the system: $\mu\nabla^2 u + (\lambda + \mu)\nabla \operatorname{div} u + lu = f$, where λ and μ are Lamé's constants, l is a parameter, and f is a given function. The displacement u is subjected either to the first boundary condition, displacement prescribed on the boundary, or to the second boundary condition, surface forces prescribed on the boundary. V. D. Kupradze ["Boundary problems in the theory of vibrations and integral equations," Moscow, 1950] has given integral equations whose kernels involve the parameter l. The author [AMR **4**, Rev. 3801] has given integral equations whose kernels involve the Green functions for the Dirichlet and Neumann problems. In the present paper the author derives integral equations whose kernels do not depend on l or on the afore-mentioned Green functions.

Courtesy of Mathematical Reviews J. B. Diaz, USA

2465. **Föppl, O., The classical theory of elasticity is not valid for the coupled state of stress $\delta_0\delta_\tau = f(x, y, z)$ [Die klassische Elastizitätstheorie gilt nicht für den gekoppelten Spannungszustand $\delta_0\,\delta\tau = f(x, y, z)$],** Braunschweig, Friedr. Vieweg & Sohn; Mitt. Wöhler Inst. no. 47, 54 pp., 1951. DM 4.

Author continues discussion along the lines of his previous papers [AMR **5**, Revs. 47, 363, 3330] with special consideration of what he calls "natural" elasticity constants (which are the bulk and shear moduli) and the compatibility equations. Specifically, the discussion refers to the bending and torsion of rods, to a sphere under radially symmetric residual stresses, and a circular cylinder under axially symmetric stress distribution. In reviewer's opinion, the general approach is not carried any further than in author's previous papers and is not as yet in a stage that can be applied to practical problems. Much un-

necessary detail and complicated notation makes the reading of the paper difficult. Reviewer feels also that the previous criticism of author's former papers is still applicable to the present one.
G. A. Zizicas, USA

2466. McKelvey, K. K., Calculation of economic reinforcement of prismatic elements of rectangular section by means of nomograms (in French), *Bull. tech. Suisse Rom.* **78,** 25, 325–334, Dec. 1952.

2467. Truesdell, C. A., A program of physical research in classical mechanics, *ZAMP* **3,** 2, 79–95, Mar. 1952.

Author urges that, in classical mechanics ("that range in theory and experiment of motion of material bodies which is governed by the classical forms of the mass, momentum, and energy principles"), laws of continua are fundamental, not laws of particles, latter being an approximate special case. "The too common opinion that the physics of this subject is totally understood rests upon a misconception that classical mechanics is the science of mass-points obeying the Hamiltonian equations." Idea that behavior of gross matter can be predicted from mass-point equations if intermolecular forces be known is dismissed, with forceful reasons.

". . . the fields of purely elastic and purely viscous behavior still offer challenges to the physicists." This note gives a simplified account of principles and novelties which invite investigation, a detailed mathematical treatment and bibliography to be given elsewhere.

Experimental foundation of the general Hooke's law in elasticity and general stress state of deformation law in viscous flow is questioned. "What experiments?" Statement that validity of linear stress-strain relation for simple shear in torsion depends on *length* of wire twisted requires correction.

In experiments on nonlinear torsion it has commonly been assumed that shearing stresses alone are sufficient to maintain shearing strains or rates of shearing. "All but a very very few of the experiments allegedly testing the classical laws of elasticity and viscosity may thus be disregarded as irrelevant." Experiments of Poynting (1909) and Privlin (1947) on axial elongation or stress due to torsion are cited as free from this defect, also Weissenberg's on viscous flow. A matrix analysis is given of second-order stress required for pure shear, and of volume and length changes occurring when this stress is wanting, the basis being Remier's general theory. Further conclusions are that "the inadequacy of the classical theories will appear more quickly in extension than in shear," and "the results of experiments on tension, no matter how accurate, are insufficient to predict the response of a material to shear, and vice versa." A later section examines similarly the shearing motion of a viscous fluid.

Range of validity of classical theory of viscosity is discussed in terms of dimensional analysis, a distinction being made between fluids which possess a physical constant of the dimension of time, and those which do not (a material possessing both a Young's modulus E and a viscosity μ has a time constant μ/E). In the former case, conclusion is that rate of deformation must be much smaller than the reciprocal time constant; in latter case, that coefficients of viscosity of all orders are independent of pressure, and that high viscosity, high rate of deformation, or low pressure serve to invalidate classical theory.

Fourteen types of research involving nonlinear mechanics are proposed in short explanatory paragraphs under the headings: Determination of moduli (beyond first order); generalization of Kelvin and Poynting effects (changes of volume and length under loadings which produce no such changes in the first order); thermodynamics; time constant of fluids; boundary conditions for fluids; capillarity; significance of multiple solutions for fluids and stability; turbulence and stability; anisotropic materials; ultrasonic studies; damping; dynamic elasticity; photoelasticity; more complicated media. J. N. Goodier, USA

2468. Sherman, D. I., On the question of the state of stress of a mountain mass between two excavations. Elastic, massive medium weakened by two elliptic holes (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 6, 840–857, June 1952.

Stresses are expressed in terms of potential functions for which series expansions are obtained. Use is made of the theory of complex functions. D. ter Haar, Scotland

2469. Vitovec, F., Relation between the atomistic glide theory and Mohr's stress theory with curved envelope (in German), Alfons Leon Gedenkschrift, Verlag Allg. Bau-Z., Wien, 82–85, 1952.

Starting from the dependence of glide velocity on the activation energy for the formation of dislocations as given in Becker's kinetic theory of plasticity, the author derives a formula for the critical shearing stress. He takes qualitatively into account the influence of lattice disturbances, of hardening, and of the pressure dependence of the activation energy. The results for the critical shearing stress as a function of hydrostatic pressure or normal stress resemble very much the results of Mohr's empirical stress theory with curved envelope of the critical Mohr circles. Some consequences of the theory are discussed briefly.
J. Meixner, Germany

2470. Bulígin, V. Ya., On elastic-plastic torsion of prismatic rods (in Russian), *Prikl. Mat. Mekh.* **16,** 1, 107–110, Jan./Feb. 1952.

This note considers the problem of elastic-plastic torsion of prismatic rods using a semi-inverse method, namely, a contour is determined for the cross section of the rod which corresponds to a prescribed form of the elastic kernel.
From author's summary

Experimental Stress Analysis

2471. Schmittner, W. G., Determination of centrifugal stresses in a turbosupercharger impeller by means of stresscoat, *Proc. Soc. exp. Stress Anal.* **10,** 2, 9–22, 1952.

A turbosupercharger impeller having an operating speed of 20,000 rpm was investigated for location of maximum stress. The sensitivity of the Stresscoat was determined by means of a four-bladed calibration device for which the centrifugal stress distribution has been calculated. This device passes through the same Stresscoat spraying and drying cycle as the impeller, and, during the tests, rotates with it. Details of technique are discussed. T. J. Dolan, USA

2472. Brewer, G. A., The SR-4 type equilateral fleximeter, *Proc. Soc. exp. Stress Anal.* **10,** 2, 1–8, 1952.

An instrument and a method are described to predict stresses on the inaccessible surface of structures; for example, steam boilers, storage vessels, and certain aircraft structures. The method calls for a separation of surface stresses into bending and uniform-load components. A fleximeter has been developed to determine the state of stress due to flexure alone, using spring-cantilevered legs with SR-4 strain gages attached. In combination with results from an SR-4 rosette on the outside surface, the inside surface stresses on the inaccessible side can be calculated.
R. K. Bernhard, USA

2473. **Frocht, M. M., and Guernsey, R., Jr., Studies in three-dimensional photoelasticity,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 301–307, 1952.

Authors present the three-dimensional counterpart of the plane stress, shear difference method of photoelasticity. Data are obtained by the freezing and slicing method, which yields three secondary principal stresses and two shears by normal incidence, and the third shear by oblique incidence. It is necessary to compute principal stresses and maximum shears from these values.

Problems associated with mechanical stress methods applied to three-dimensional photoelasticity (because Poisson's ratio approaches one half at the freezing temperature of common photoelastic plastics) are discussed. The authors report high accuracy in applying the method to a diametrally compressed sphere. H. Becker, USA

2474. **Jasper, N. H., The TMB strain cycle gage and counter. An instrument for the statistical determination of the strain history of structures,** *Proc. Soc. exp. Stress Anal.* **10,** 1, 87–96, 1952.

The gage and counter discussed in this paper will automatically analyze the strain history at the location of the gage in terms of the number of cycles of given amplitudes that have occurred. These cyclic variations can be automatically tabulated or classified according to the mean strain about which they took place.
From author's summary

2475. **Frocht, M. M., and Guernsey, R., Jr., A special investigation to develop a general method for three-dimensional photoelastic stress analysis,** *NACA TN* 2822, 59 pp., Dec. 1952.

A new method for three-dimensional photoelastic investigation is explained, using two sets of slices after the freezing process, but avoiding strain measurements. By observations of the two sets of slices in polarized light with normal and oblique incidence, a sufficient number of conditions are obtained to derive all six components of stress. H. Neuber, Germany

Rods, Beams, Shafts, Springs, Cables, etc.

2476. **Miyagawa, M., Some notes on beams under moving loads,** *Mem. Fac. Technol., Tokyo Metrop. Univ.* no. 2, 55–61, 1952.

Minor modifications of methods for obtaining shear and moment envelopes of simple beams without and with floor beams.
G. Winter, USA

✎2477. **Kulmann, C. A., Nomographic charts,** New York, Toronto, London; McGraw-Hill Book Co., Inc., 1951, xi + 244 pp. $6.50.

Author divides the ninety-two nomographs into six groups. Group I: Function scales—mainly fractional and integral powers of numbers. Group II: General charts—annuity calculations, properties of plane figures. Group III: Hydraulic charts—weir discharge, pipe flow, surge pressure, hydraulic turbines, rainfall, etc. Group IV: Mechanics charts—beam calculations, helical springs, belt designs, torsions, etc. Group V: Thermodynamic charts—flow in orifices and pipes, heat losses, boiler efficiency, etc. Group VI: Electrical charts—power factor, hyperbolic functions, transmission line, and other power engineering calculations.

These charts are easily applied to many common engineering problems. Since there are a few charts in several field books, it is probably of most interest to librarians and consulting engineers. C. C. Gotlieb, Canada

2478. **Zerna, W., On the analysis of boundary disturbances of circular cylindrical shells** (in German), *Ing.-Arch.* **20,** 5, 357–362, 1952.

The paper treats the effect of line loads along the longitudinal edges of circular cylindrical shells. The solution is obtained by means of the mathematical theory of elasticity, expressing the internal forces in terms of the elastic displacements. Substituting these expressions in the equilibrium conditions, a sufficient number of equations is obtained for the determination of displacements and internal forces.

The author expresses the normal forces and their equilibrium as in the case of a flat plate, except for the additional transverse force caused by the displacement normal to the shell. The moment expressions are those derived for a flat plate. The normal forces are expressed in terms of an Airy function Φ, while the moments are given in terms of the normal displacement w. The resulting two simultaneous differential equations determining these two unknowns have differential operators which differ only in the constant. The equations are solved by the introduction of a complex function $\psi = w + iK\Phi$, which is a linear combination of the previous two unknowns. Consequently, also ψ is given by a fourth-order differential equation of the same type as those for w and Φ. The real part of ψ gives w and the internal moments, while the imaginary part determines the normal forces.

Finally, real expressions are given for w, Φ, normal forces, moments, and displacements. A. Aas-Jakobsen, Norway

Plates, Disks, Shells, Membranes

(See also Rev. 2490)

2479. **Saito, H., On the stress distribution in a rotating thick circular disk of constant thickness** (in Japanese), *Trans. Soc. mech. Engrs. Japan* **18,** 75, 40–43, Nov. 1952.

An exact three-dimensional solution is described about the stress distribution in a thick circular disk or a short circular cylinder of constant thickness which is freely rotating about the central axis. Starting from the equations of equilibrium and compatibility, a solution is first derived which satisfies only the boundary conditions of no shearing stresses on the circumferential and both end surfaces. Then, from the boundary conditions of no normal tractions on all the surfaces, a system of linear conditional equations about infinite numbers of the coefficients contained in the preceding solution is derived. Solving the equations by means of successive approximations, the required stresses are found. A numerical example where the axial length is equal to the diameter shows that the maximum stress at the center in the middle plane is higher by about 6% than the two-dimensional result of a thin disk, and about 3% higher than that of an infinitely long cylinder. T. Udoguchi, Japan

2480. **Wallner, E., The bearing capacity of cross-reinforced plates at failure. Consideration of test results on basis of ideal plasticity** (in German), Doctor-thesis, Graz, Austria, 1950, 62 pp.

Purpose of thesis is to compare bearing capacity as predicted by K. W. Johansen's plastic theory ["Brudlinieteorier," Kopenhague, 1943] with actual behavior of tests by the DAfE (German Board for Reinforced Concrete). Theoretical moments per unit length of fracture lines are expressed in form $m = aP + bG$ (P load at failure, G own weight, a, b coefficients depending on manner of support and loading). Plates were subjected to 16 (Stuttgart) and 64 (Dresden) single loads, respectively, regularly distributed across surface of plate; this is taken into account in computation of coefficients.

For each plate a strip of the same dimensions and loaded in a

statically determinate fashion was tested so that its moment at failure m_b could be determined. Ratio m/m_b then is a measure for reliability of plastic theory. Average and standard deviation (computed by reviewer) are 1.13 and 0.19.

Carrying capacity of cross sections of strips has also been directly determined by plastic theory, i.e., by inserting yield stress of steel and crushing strength of concrete. Most values m_s thus obtained are smaller than m_b since most strips entered strain-hardening range. Therefore, ratios m/m_s are larger than m/m_b.

It is to be regretted that German tests with plates subjected to single loads at center have not been evaluated because, in this case, plastic theory enormously simplifies design. In view of the little information available, however, thesis is a welcome document which fully verifies plastic theory.

H. Craemer, Germany-Egypt

2481. Udoguchi, T., On the strength of rotating bodies (in Japanese), *J. Soc. mech. Engrs. Japan* **55,** 402, 474–480, July 1952.

The maximum hoop stress in a rotating disk, as calculated by the usual elasticity theory corresponding to the observed bursting speed, is much higher than the ultimate strength of the material measured in a simple tension test. Tests are carried out to determine the bursting speed of a number of rotating disks made of gypsum, hollow as well as solid. Results show that the criterion for rupture is furnished by the average stress theory, which states that the disk fails when the average stress over the diametral section reaches the ultimate strength of the material, but not by the usual elastic stress theory. The results with disks containing eccentric holes also agree well with the average stress theory.

Some theoretical considerations about the failure of disks made of ductile material are described and compared with the experiments carried out by A. G. Holms and J. E. Jenkins at NACA in the United States. I. Imai, Japan

2482. Udoguchi, T., Rupture of rotating disks (in Japanese), *Science of Machine, Tokyo* **5,** 1, 11–18, Jan. 1953.

Reviews of researches about rupture of rotating disks are given, together with author's experimental results on gypsum and graphite disks and remarks concerning the average stress theory and the modified average stress theory. Some photoelastic stress measurements on rotating disks by means of stress-freezing method are also given. I. Imai, Japan

2483. Bijlaard, P. P., On the optimum distribution of material in sandwich plates loaded in their plane, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 373–380, 1952.

For a sandwich plate with given thickness and given weight per unit surface, the ratio of elastic moduli of core and faces is computed. For given boundary conditions and material properties, this ratio is practically the same for all thicknesses and is proportional to the weight of the plate. If the thus obtained long wave buckling load is higher than the critical load for wrinkling, the moduli ratio for which these two loads are equal yields the maximum load.

Assuming a material of which the elastic modulus varies proportionately to its density, the optimum continuous distribution of material in a plate, subjected to compression or shear in its own plane, is computed by calculus of variation. Also, a plate with five different layers is considered. Only isotropic material and elastic buckling are considered. Simple results are obtained by introducing minor approximations, such as neglect of the difference in warping of the cross sections.

From author's summary by F. K. Teichmann, USA

2484. Szabó, I., Contributions to the theory of the axial symmetrically loaded, heavy and thick circular plate (in German), *ZAMM* **32,** 11/12, 359–371, Nov./Dec. 1952.

Paper is an extension of previous work by the author [AMR, **5,** Revs. 1033, 2317]. It deals with a thick circular plate on an elastic foundation, built-in at the circular edge or freely supported at this edge, and, in contrast to the former publications, the mass forces due to the weight of the plate are taken into account. Solutions for the displacements and stresses due to the weight are superimposed on those already obtained. The equilibrium conditions at the vertical outer circular edge of the plate are not completely satisfied, but the resultant of all stresses at this outer edge is zero for all sectors.

By built-in is meant that the radial stresses at the vertical outer circular edge (and their resultant in each sector) have a nonzero value, but the sheer stresses (and radial displacements) are zero. Vertical load and weight are, in this case, carried by a uniformly distributed annular load at the lower flat side.

J. P. Benthem, Holland

2485. Woinowsky-Krieger, S., On the use of the Mellin inversion theorem for the solution of problems in the theory of bending of plates (in German), *Ing.-Arch.* **20,** 6, 391–397, 1952.

It is shown that the linear vertical deflection $w(r, \vartheta)$ of plates of circular-sectorial shape and subjected to various types of external loadings and boundary conditions may efficiently be evaluated by use of the transformation

$$w(r, \vartheta) = (1/2\pi i) \int_{\sigma-i\infty}^{\sigma+i\infty} r^{-s} f(s, \vartheta)\, ds$$

determination of the function $f(s, \vartheta)$, and subsequent evaluation of $w(r, \vartheta)$ by direct transformation of the complex integral or contour integration. Here r and ϑ denote the radial and angular coordinates of the plate referred to its vertex and one of its two radial edges. The method is applicable to cases where one or both edges of the plate are clamped, and corresponding to concentrated or continuous external loading functions. Procedure demonstrates its greatest advantages in the case where the plate edges are considered as of infinite length. The plate deformations known, conclusions may be drawn with respect to the state of stresses over the whole region of the plate including the triangular domain around its center. This possibility is of specific interest in view of the fact that there are but few procedures known which accurately predict the stresses in this singular region. M. A. Dengler, USA

2486. Williams, M. L., Surface stress singularities resulting from various boundary conditions in angular corners of plates under bending, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 325–329, 1952.

The character of the stresses near the central corner of a thin sector plate is determined for various combinations of free, clamped, and supported boundary conditions along the radial edges.

Solutions of the classical homogeneous equation for thin plates in polar coordinates are obtained in terms of eigenfunctions satisfying the radial-edge boundary conditions. The deflection function for the plate with lateral loading is expressed as a sum of the particular solution and a series of the eigenfunctions. The coefficients of the series can then be evaluated to satisfy the boundary conditions along the circumferential edge. Expressions for the radial and tangential surface stresses are obtained, using only the first term of the eigenfunction expansion.

It is shown that the stresses at the central corner of the plate are unbounded if the eigenvalues are less than unity. No stress singularity occurs for sector plates having a central angle less

than 90°. For angles greater than 90° a stress singularity occurs for the plates with both radial edges supported, one edge supported and one free, and one edge clamped and one free.

M. V. Barton, USA

2487. **Oniashvili, O. D., On the computation of sloping shells with a horizontal force** (in Russian), *Soobshch. Akad. Nauk Gruz. SSR* 12, 103–110, 1951.

A shell supported radially at the edges presents the simplest boundary problem, and it is solved by a well-known double trigonometric series. If only one of the edges is not supported radially, the case is not so simple. In such a case, the author recommends using a single trigonometric series or a variational method. The use of a single trigonometric series is illustrated on three examples. In the first example, we have a spherical momentless shell with two radially supported edges, the supports of the remaining two edges are arbitrary. The load distributed on the entire surface is continuous, constant, and directed radially. In the second example, the same spherical shell with the same supports has horizontal continuously distributed load. The third example deals with a cylindrical shell loaded by horizontal forces. The bending moments in this case are not neglected. The supports are as in the above two examples. The use of a variational method is illustrated on the last example. The author solves a case of a shell whose shape and supports are arbitrary. He utilizes in this problem the functions which are often used for transverse vibrations of a beam.

Courtesy of Mathematical Reviews T. Leser, USA

Buckling Problems

(See also Rev. 2483)

2488. **Uemura, M., and Yoshimura, Y., The buckling of spherical shells by external pressure (2nd report)** (in Japanese), *Rep. Inst. Sci. Technol. Tokyo* **6**, 6, 367–371, Dec. 1952.

The buckling of spherical shells under constant external pressure is treated from the energy viewpoint, based on the pressure-deflection relation obtained previously from the equilibrium equations of the shell under reasonable assumptions. The theoretical values of the lower buckling load, the angle of the buckled part relative to the center of the sphere, and the deflection after buckling, are in satisfactory agreement with experimental results. The energy barrier to be jumped over in buckling is reduced to a small, reasonable value, based on the idea that the buckling may extend progressively from a certain small segment of the shell to the final stable state.

Since the present investigation was accomplished, the writers have learned of the paper by H. S. Tsien, based on the same viewpoint as this paper, which was unknown to them owing to World War II. The reason they publish the present paper, nevertheless, is that the present method is more exact, and their concept as to the energy barrier is considered to be in advance of Tsien's results.

From authors' summary

2489. **Martin, H. C., Elastic instability of deep cantilever struts under combined axial and shear loads at the free end,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 395–402, 1952.

The problem investigated is the elastic instability of deep cantilever struts subjected to a load at the free end. The load is in the plane of the strut but is inclined at an arbitrary angle with respect to the horizontal axis of the strut.

The usual assumptions and procedures used in deriving the elementary beam equation are also used here. In this case, the load gives rise to twisting moments as well as bending moments, and the effects of both are considered.

The differential equation obtained is a fourth-order ordinary linear differential equation. This equation together with the boundary conditions represents the mathematical formulation of the physical problem. Solutions were obtained by expansion in power series.

In the case of the uniform strut, for the special cases $\phi = 0$ and $\phi = 90°$, the solutions agree with those previously obtained for the Euler column problem and the Prandtl deep-beam problem.

In the case of the tapered strut, for the special cases $\phi = 0$ and $\phi = 90°$, the solutions agree with those obtained previously by Dinnik and Federhofer. Experiments were also conducted for uniform struts, and agreement between theory and experiment was observed to be good.

The author states that this problem is of practical importance, since struts of the type investigated are used as support members for aerodynamic models in wind-tunnel tests, and it is necessary to guard against instability of those supports.

Y.-H. Pao, USA

2490. **Austin, W. J., and Newmark, N. M., A numerical method for the solution of plate buckling problems,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 363–371, 1952.

An iteration scheme is presented for determining the buckling load of constant-thickness rectangular plates with boundary conditions and edge loadings which admit simple sinusoidal transverse deflection patterns in the loaded direction, with undetermined amplitudes in the unloaded direction. Thus the linear partial-differential equation of elastic stability is reduced to an ordinary differential equation in the plate interior with ordinary differential equations as boundary conditions. A numerical integration procedure previously developed by Newmark is combined with the Stodola-Vianello method for determining the eigenvalues of the differential equation.

Reviewer believes that the paper suffers from two limitations in its present form. The boundary condition and loading restrictions limit its application to problems which can be handled satisfactorily by classical methods. In addition, convergence is uncertain for different loading combinations. However, if convergence is achieved, the approximation to the buckling load appears to be approached from below, resulting in a conservative answer.

N. Grossman, USA

Structures

(See also Revs. 2448, 2480, 2524, 2526, 2527, 2530, 2531, 2539, 2540 2542, 2545, 2546, 2550, 2551, 2552, 2651)

2491. **Pagano, M., On the calculation of a continuous elastic system consisting of curved elements with movable intermediate supports,** *G. Gen. civ.* **90**, 7/8, 401–414, July/Aug. 1952.

A modification of the Cross method, suitable for continuous arches on movable supports and similar structures, is presented in this paper. Formulas for the computation of the distribution and carry-over factors are derived, taking into account the combined effect of joint displacement and rotation. By using those modified factors, a faster convergence of the moment-distribution method is attained.

A comparison between the ordinary procedure and the one suggested in the paper is made for a roof frame constituted by eleven equal shed-type polygonal arches. The maximum un-

equilibrated horizontal shear after one cycle of the new procedure is about 23% of that obtained after ten cycles with the usual method. E. Saleme, USA

2492. de Guillenchmidt, P., Elements of analysis of airplane structures [Éléments de calcul de construction aéronautique], 2nd ed., Paris, Editions Chiron, 618 pp. 3000 Fr. fr.

This book combines the functions of a structural handbook, of a text in strength of materials, and of a text for a first course in aircraft structures. It is divided in two parts, entitled, respectively, Tables, formulas; General information and strength of materials as applied in aviation. The first part includes, in addition to some useful tables, basic information on circular and hyperbolic trigonometry, algebra, curve construction, numerical determination of areas, volumes, center of gravity, and moments of inertia; also given are tables of properties of steel, aluminum and magnesium alloys, wood, and charts for the crippling load of various types of members.

The second part deals with the analysis of bars in tension and compression, beams (with extensive tables of beams under various loadings and supports), columns, beam columns, continuous beams, shear stresses, the shear center, the calculation of joints and connections, thin-walled beams in bending and torsion, solid bars in torsion, torsion with restrained warping, bending of plates and membranes, tension-field beams, designs with wood, determinate and indeterminate trusses, rigid frames, arches and rings. Some derivations are given, many are not; but in all cases, the information necessary for actual calculations is given with very good explanatory remarks.

This is primarily a practical book, one that makes no pretense at originality of content; but it is remarkably well organized, very clear, and quite comprehensive. As such it should be of great use either as an elementary text or as a reference book.

B. A. Boley, USA

2493. Ziesemer, H., Ready-for-use formulas for a nonarticulated arc (in German), *Beton u. Stahlbetonbau* **47,** 11, 259–263, Nov. 1952.

Formulas are presented for computing moments and forces in hingeless, circular arch ribs of constant section. Various load conditions are considered.

In 1950, this reviewer obtained exact expressions for moments and forces in circular, parabolic, and semi-elliptic fixed arches of constant section. In a Master of Science thesis written under his direction ["Influence lines for the design of hingeless arches," by R. R. Robinson, Iowa State College, Ames, Iowa], exact influence lines are presented for the above cases, and studies are made of the effect of variation in shape and cross section of the arch. J. P. Michalos, USA

2494. Yu, Y.-Y., Gravitational stresses on deep tunnels, *J. appl. Mech.* **19,** 4, 537–542, Dec. 1952.

The solution is given for a hole in an elastic medium in which the pressure—equal to the overburden—acts in the vertical as well as in the horizontal direction. Advanced mathematical investigation uses stress function in the form of the functions of a complex variable (Muskhelishvili). For a circular hole in great depth, the circumferential pressure at the boundary of the hole equals twice the pressure in the rock prior to the excavation of the hole; this solution is known. Practical use of the solution is limited by the fact that in rocks the pressure at rest is generally not equal with the vertical pressure, whereas in rocks with great horizontal pressure a plastic zone develops around the hole.

V. Mencl, Czechoslovakia

2495. Rousselier, Lining of galleries (in French), *Ann. Inst. tech. Bât. Trav. publics* **5,** 59, 1110–1128, Nov. 1952.

After considering briefly the economic aspect of different types of linings and their protection to rocks, author summarizes results of measurements of deformation of galleries in various rocks. Finally, the construction of reinforced-concrete and steel linings is illustrated by typical cases in practice.

G. G. Meyerhof, England

THE FOLLOWING PAPERS (REVS. 2496–2508) WERE PUBLISHED IN *Trans. Fourth Congr. Inter. Comm. Large Dams,* New Delhi, Jan. 1951, 4 vols. $48 per set.

2496. Saarivirta, N., and Korvenkontio, O., Earth dams of Jylhämä Power Plant, vol. I, 33–46.

2497. Steer, E. C., and Binnie, G. M., Design and construction of earth dams, core walls and diaphragms of earth and rock-fill dams, vol. I, 47–66.

Paper deals with the design and construction of earth dams and with core walls and diaphragms of earth and rock-fill dams. No attempt is made to deal exhaustively with the subject which covers too wide a field to be compressed into a paper of the length prescribed, and the authors have almost entirely confined themselves to describing the design and construction of earth dams as exemplified by the latest developments in British practice. From authors' summary

2498. Westerberg, G., Pira, G., Hagrup, J., Description of some Swedish earth and rock-fill dams with concrete core walls and measurements of the movements and pressure in the filling material and the core walls, vol. I, 67–97.

The dams described in this report consist of an impervious portion composed of a concrete core wall and, in front of this, a layer of impervious earth material. The impervious portion is enclosed on each side by supporting zones of earth or rock fill. The rock and earth materials from the excavation operations for the power station and the conduits have been used for the supporting portions.

Measurements of vertical and horizontal movements of the dams and of pressure in the filling materials and the concrete core wall have been carried out. In addition, seepage through the dams and the ground has been measured. For the measurement of the deflection of the concrete core wall and the settlements of the downstream filling, observation wells have been employed.

From authors' summary

2499. Niederhoff, A. E., High earth dams on pervious foundations, vol. I, 165–187.

It is the purpose of this paper to show: (1) That there are several methods and many combinations of methods for treating pervious foundations. (2) That many high earth dams have been built successfully on unconsolidated and permeable foundations. (3) That an earth dam is the only suitable type to build where foundations have a low value in shear. (4) That the amount of leakage through an earth dam and a pervious foundation can be predicted within reasonably close limits. (5) That apparently no limit exists for the height of an earth dam or for the volume of material placed in the embankment. Larger and faster earth-moving machinery has accounted for successful building of large earth dams. The judicious use of explosives in moving earth and damming rivers may be the next step forward. From author's summary

2500. **Bock, R. W., and Collins, W. E., Design and construction of Bureau of Reclamation earth dams in the Missouri River Basin project,** vol. 1, 247–258.

2501. **Rao, K. L., Earth dams, ancient and modern, in Madras State (moderate height),** vol. I, 259–301.

2502. **Frontard, Design and construction of earth dams and rock-fill dams with their core walls and diaphragms** (in French), vol. I, 343–395.

In first section of paper, author gives a review of upstream bank slidings which have occurred in French earth dams of rather old type (construction before 1920). Methods used for repairing are also explained and discussed.

Second section is devoted to general problems of stability of earth slopes and determination of dangerous height, for which author recalls his own theory based on cycloidal lines of sliding and compares it with well-known circular-arc method, showing that the latter gives dangerous heights larger than author's formulas.

Third and fourth sections deal with applications of author's theory to problems of actual design. G. Evangelisti, Italy

2503. **Cathabard, A., Lavaud-Gelade Dam** (in French), vol. I, 413–429.

2504. **Bellier, J., and Chervier, L., Extensometric measurements in the bedrock and in the concrete of a thin arch dam** (in French), vol. IV, 399–411.

Extensometric measurements made in the bedrock and in the concrete of a thin arch dam during the filling of the reservoir have shown clearly the great deformability of the granulite bedrock in vicinity of the dam. Under the crown cantilever, the soil deformations are 3 to 8 times greater than those of adjacent concrete. At the abutment of the lower third arch, soil deformations range from 250 to 350 microns per meter, while those of concrete in the vicinity are practically null. As a consequence, the embedding stresses and particularly the extensions are substantially reduced.

From authors' summary

2505. **Capdecomme, L., Farran, J., and Orliac, M., On the use of mineralogical testing techniques for dam-building materials** (in French), vol. IV, 419–430.

2506. **Hellström, B., and Berg, L., Nissastrom rock-fill dam,** vol. IV, 447–452.

2507. **de Morais, A. T., and de Palma Carlos, A., Design and construction of earth-fill and rock-fill dams and their waterproofing blankets. Salazar (Pego Do Altar) and Vale Do Gaio Dams, Vale Do Sado irrigation scheme of the Junta Autonoma das Obras de Hidraulica Agricola,** vol. IV, 453–476.

2508. **Nunes, J. M. O., The air-entrained concrete of Castelo Do Bode Dam,** vol. IV, 477–484.

2509. **Fischer, G., Analysis of the deck of the Bürgermeister-Smidt bridge in Bremen** (in German), *Stahlbau* **21,** 11, 12; 213–219, 237–244; Nov., Dec. 1952.

In recent works [AMR **5,** Rev. 417; **6,** Rev. 441], building gridworks, or bridge floors, have been calculated by methods ranging from beams statics to continuous statics, the latter employing the anisotropic-plate differential equation. In this article, author gives another solution using difference equations and taking the finite distances between elements of the bridge floor. The calculation is developed in two parts: (1) The bridge floor is made of isolated beams X and a set of continuous beams Y; (2) then isolated beams X are supposed to act together with intermediate, continuous plates. Following, it is assumed that (3) the beams in the Y direction have torsional stiffness; (4) the same for the X beams; (5) elastic clamping for the beams in the X direction.

A. M. Guzmán, Argentina

2510. **Foster, G. M., Test on rolled-beam bridge using H20-S16 loading,** *Nat. Res. Counc. Highway Res. Bd. Res. Rep.* 14-B, 10–38, 1952.

Static and dynamic tests of simple-span slab-and-stringer highway bridge under actual truck loading. Test structure consisted of six simple spans, in one of which the concrete slab was anchored to the steel stringers. Other variables included number and location of transverse diaphragms between stringers, lateral placement of truck, speed of truck, and impact caused by vehicle wheel passing over 3/4-in. plate on roadway. Results presented include: load distribution to stringers, stresses in diaphragms, strains in concrete deck, and dynamic strains and deflections.

C. P. Siess, USA

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 2470, 2480, 2523, 2584, 2638)

2511. **Gallagher, C. J., Plastic deformation of germanium and silicon,** *Phys. Rev.* (2) **88,** 4, 721–722, Nov. 1952.

Single crystals of germanium and silicon become plastic above 500 C and 900 C, respectively. Slip lines appear in tensile and bend specimens in (111)-planes; slip direction has not yet been definitely established. At temperatures below 600 C, germanium exhibits an induction time ($\sim$2.5 and $\sim$6 min at 550 and 500 C, respectively) at constant stress. Deformed germanium, originally n-type, remains n-type; electrical resistivity is increased, and lifetime of photo-injected carriers is considerably decreased.

A. Kochendörfer, Germany

2512. **Seitz, F., The plasticity of silicon and germanium,** *Phys. Rev.* (2) **88,** 4, 722–724, Nov. 1952.

A qualitative analysis of Gallagher's measurements (see preceding review) is made. It is supposed that slip occurs by dislocations in (111)-planes with Burger's vector equal to an allowed translation in [1$\bar{1}$0]-direction. Observed incubation time is related to freeing by thermal fluctuations of locking points of Cottrell type associated with broken bonds along nearly pure screw dislocations with small edge components. It is proposed that foreign atoms reside at the broken bonds in normal materials. A discrepancy in the coefficient of the Boltzmann factor indicates, however, that these concepts cannot be applied in their most simple form. Analogy between considered and Kramer and Maddin's measurements in β-brass [AMR **5,** Rev. 2828] is pointed out.

From author's summary by A. Kochendörfer, Germany

2513. **Drucker, D. C., A more fundamental approach to plastic stress-strain relations,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 487–491, 1952.

Author defines work-hardening by considering the work done by an external agency which slowly applies an additional set of stresses to the already stressed material and then slowly removes the added set. Work-hardening means that (a) positive

work is done by the external agency during the application of the added set of stresses, and (b) the network performed by the external agency over the cycle is zero if and only if purely elastic changes in strain are produced; plastic deformation is accompanied by positive network. From this definition and assumption of the existence of a loading function, author derives convexity of the loading surface, normality of plastic strain increment vector, and the von Mises-Prager plastic potential stress-strain relations. Theory is also extended to ideally plastic materials.

J. Heyman, England

2514. Geiringer von Mises, Hilda, Fundamentals of a mathematical theory of plasticity (in Italian), *Cons. naz. Ric.* no. 358, 15 pp., 1953 = *R. C. Mat. Appl.* (5) **11**, 3/4, 1952.

Author presents a condensed and simplified introduction into the fundamental concepts of the mathematical theory of plasticity. After the equilibrium conditions for normal stresses σ_x, σ_y, σ_z and shear stresses τ_x, τ_y, τ_z are discussed, the yield condition $\sigma_i \leq \sigma^*$ is imposed. Finally the fundamental proportionality relation grad $h = k \cdot \dot{E}$ between the tensor gradient of the plasticity potential $h(\sigma_x, \sigma_y, \sigma_z, \tau_x, \tau_y, \tau_z)$ and the dilatation $\dot{E}$ of the velocity of deformation $\mathfrak{v} = (v_x, v_y, v_z)$ is established. General methods of solution of boundary-value problems in plasticity theory are briefly analyzed. M. A. Dengler, USA

2515. Geiringer, H., On the characteristics of the complete plane plasticity problem (in German), *ZAMM* **32**, 11/12, 379–387, Nov./Dec. 1952.

Author discusses three pairs of families of curves which define a two-dimensional problem: The stress characteristics, the velocity characteristics, and the shear lines. For plane strain, all three coincide in so-called slip lines. For plane stress, first two will coincide if, and only if, velocity potential is identical with yield function. Author discusses case where all three are different. Treatment is purely mathematical. P. G. Hodge, Jr., USA

2516. Staverman, A. J., and Schwarzl, F., Thermodynamics of viscoelastic behaviour (model theory), *Proc. k. Ned. Akad. Wet.* **55**, 5, 474–485, Nov./Dec. 1952.

The question investigated is whether the behavior of viscoelastic materials can be described in terms of a mechanical model of springs and dashpots. It is shown that such models are thermodynamically equivalent when they are mechanically equivalent (in the same sense that electrical circuits can be equivalent). However, a mechanical model can only be an exact representation if certain conditions hold in the microscopic behavior of the materials. For example, the above equivalence is true only if the mechanical components are connected with rigid rods. It is not yet clear what the corresponding condition in terms of the microscopic (molecular) structure would be.

G. W. King, USA

2517. Staverman, A. J., and Schwarzl, F., Non-equilibrium thermodynamics of viscoelastic behaviour, *Proc. k. Ned. Akad. Wet.* **55**, 5, 486–492, Nov./Dec. 1952.

Within linear region, the theory of small deviations of dynamical systems can be applied to treatment of viscoelastic solids. A free energy can be defined that is a quadratic function of a set of parameters (generalized coordinates) describing deviation from equilibrium value. Generally, interaction terms will appear, i.e., the energy expression contains mixed products of the generalized coordinates. However, in consequence of the linearity of the system, a linear transformation of coordinates can be found such that the mixed products are zero. The new coordinates are the normal coordinates or normal modes of the system. The set of normal modes is associated with a corresponding set of molecular processes which behave independently. The characteristic time constants of these molecular processes are identical with the characteristic times of the relaxation spectrum. Finally, the principle of superposition is established and the time dependence of the free energy during a relaxation process calculated. The latter is possible because the total value of the free energy is equal to the sum of the free energies of the independent elementary processes. B. Gross, Brazil

2518. Geleji, A., Extrusion presses and press-punching (in German), *Acta Techn. Hung., Budapest* **4**, 1–4, 273–292, 1952.

Article gives derivation of formulas for calculating, within practical accuracy, the force and power required in plain and impact extrusion of metals at various speeds. The theory is based on the analogy between die-drawing and extrusion and on the effect of the displacements within the material being extruded.

From author's summary by D. Kececioglu, USA

2519. Shevchenko, K. N., Plane elastic-plastic deformation of a cylinder loaded by a balanced system of two concentrated forces (in Russian), *Prikl. Mat. Mekh.* **16**, 1, 35–44, 1952.

It is known from experiments that compression of a sphere between two plane-surfaced plungers produces cracks at the center, while rolling produces cavities. The present paper presents an effort to explain the quite complicated mechanism of formation of cavities by means of an approximate model. A more detailed study of this phenomenon will require a great deal of work. Here author considers the plane problem of distribution of elastic and plastic deformations in a section of the cylinder subjected to the action of two concentrated forces. In the plastic region an approximate solution is obtained under the assumption of incompressibility of the material.

From author's summary by H. I. Ansoff, USA

Courtesy of Mathematical Reviews

2520. Klein, N., Rheological properties of a high asphaltene content bitumen, *Bull. Res. Counc. Israel* **2**, 1, p. 66, June 1952.

Paper briefly describes shear displacement and recovery experiments with single sample of asphalt using a coni-cylindrical viscometer. Author concludes that molecular constitution of asphalt is not colloidal but is analogous to solution of high molecular weight molecules in low molecular weight solvent. Reviewer notes that asphaltene content of this asphalt (12.6%) is not high, as indicated in title of paper, but is low, compared to most asphalts. Experimental description is very brief and data are presented graphically. J. T. Bergen, USA

Failure, Mechanics of Solid State

2521. Lissner, O., Influence of stress and temperature in stress-corrosion tests (in German), *Z. Metallk.* **43**, 5, 147–150, May 1952.

The idea that, in stress-corrosion tests, specimen life and stress give a straight line when plotted against each other in double logarithmic representation is justified by study of existing data taken from the literature and by theoretical considerations. The logarithm of specimen life also plots as a straight line against the reciprocal of absolute temperature. The presence of a knee in some of these straight lines is attributed to plastic yielding.

A. D. Topping, USA

2522. **Hartman, A., and Duyn, G. C., A comparative investigation on the fatigue strength at fluctuating tension of several types of riveted lap joints, a series of bolted and some series of glued lap joints of 24S-T alclad,** *Nat. LuchtLab. Amsterdam Rap.* M. 1857, 26 pp., 1952.

Results of fatigue tests at fluctuating tension on various standard types of riveted joints in 24S-T alclad. Included in the investigation are some tests on bolted and glued single lap joints.

The most important results are: In-line or staggered riveting had no influence on the endurance strength of the specimens with thin sheets. In fatigue loading all the riveted joints gave nearly the same failing stresses. Larger static strength was not coupled with increased fatigue strength. The bonded joint at low stress level and the bolted joint at both high and low stress level had somewhat higher fatigue strengths than the riveted joint. From authors' summary

2523. **Hoff, N. J., The necking and the rupture of rods subjected to constant tensile loads,** *J. appl. Mech.* **20,** 1, 105–108, Mar. 1953.

Paper discusses the effect of the increase in stress due to the decrease in diameter that occurs during a constant-load creep test. After neglecting the effect of strain-hardening and the decrease in rate during the first part of a creep test, the author works out expressions for the time to rupture and the profile of the necked region. The theoretical rupture time is compared with experimental results on an aluminum alloy.

E. A. Davis, USA

THE FOLLOWING PAPERS (REVS. 2524–2532) WERE PUBLISHED IN *Trans. Fourth Congr. Inter. Comm. Large Dams,* New Delhi, Jan. 1951, 4 vols. $48 per set.

2524. **Fritsch, J., Cracks in the "Vermunt" gravity dam of the "Vorarberger Illwerke A.G."** (in French), vol. III, 105–107.

The gravity dam "Vermunt" of the "Vorarberger Illwerke A.G." shows a number of characteristic cracks. The cause lies in the fact that the dam was built by using unusually large lengths of monolith. From author's summary

2525. **Westerberg, G., Absence of cracks in a special type of concrete dam,** vol. III, 123–127.

2526. **Roberts, C. M., Cement variations as affecting cracking in large dams,** vol. III, 129–154.

Factors which affect watertightness and cracking of mass concrete dams include variations in cement content and type, the former being to some extent dependent on the nature of the aggregates, the water-cement ratio adopted, and construction methods. A low cement content is recommended as having a very favorable influence on these properties, since the disadvantages of lean mixes, such as low durability and low workability, can be overcome by improvements in cements or by special methods of construction. Low cement contents can be achieved by selection of suitable aggregates to reduce water demand, by the control of grading to insure high workability, and by the use of additives.

A cement for mass concrete should have a rate of heat evolution suited to the construction methods adopted. Many cements are now available, with widely differing characteristics of heat evolution, strength development, and resistance to acid and sulphate attack. Low-heat and supersulphated cements appear to be the most promising at present.

The temperature rise in concrete is affected by placing temperature, placing cycles, lift thickness, exposure conditions, and various other factors. A comparison is made of the heat evolutions of a low-heat and an ordinary Portland cement.

From author's summary

2527. **Raphael, J. M., and Rawhouser, C., Cracking caused by internal stresses in large dams,** vol. III, 189–198.

2528. **Lee, C. R., Creep and shrinkage in restrained concrete,** vol. III, 215–230.

After briefly reviewing published information on creep in concrete under constant stress, reference is made to the comparatively scanty direct experimental data on the effects of creep on the development of temperature or shrinkage stresses under conditions of restraint such as occur in mass concrete structures. Methods of calculating the effects of creep in the latter conditions from data on creep under constant stress are discussed, and it is suggested that creep in concrete can be regarded as a long-continuing viscous flow combined with a short-term delayed elastic effect. From author's summary

2529. **Hoon, R. C., Development of Portland Pozzolan cements for mass concrete construction,** vol. III, 285–305.

Portland pozzolan cements combine the desirable features of hydraulic limes and Portland cement and seem to have all the desirable characteristics for mass concrete work. The potentialities of pozzolan cement are indeed great in this country where there are vast natural deposits of siliceous materials suitable for use as pozzolana which can be made use of. The employment of pozzolan cement as construction material will not only lower the cost but also help to conserve cement. This is particularly important at the present juncture when India is embarking on huge construction programs, including a number of major hydroelectric development projects.

From author's summary

2530. **Hupner, H., Cracking of dams. Results of investigations on the main dams of France** (in French), vol. III, 355–379.

The Technical Department of the "Grands Barrages" undertook to investigate the cracking of dams. The survey included about thirty French structures of different types: gravity dams, arch dams, and multiple arch dams. No fissures were observed in twelve of the structures examined. For each of the dams in which cracks were discovered, the report indicated the main characteristics of the construction, the fissures observed, and their probable causes. From author's summary

2531. **Lazard, A., Predetermination of fissures** (in French), vol. III, 381–386.

2532. **Kratochvil, St., and Lossmann, K., Cracks in two concrete gravity dams** (in French), vol. III, 559–566.

Material Test Techniques

(See also Rev. 2555)

2533. **Craemer, H., Dependence of strength on test specimen size, considered on the basis of probability theory** (in German), *Öst. Ing.-Arch.* **6,** 3, 145–157, May 1952.

Author asserts that the strength of the material is a function of specimen size. An explanation is given on the basis of the nonuniformity of the material. It is represented by a function of the standard deviation of the strength values. The standard

deviation is less for large specimens than for smaller ones. Longer pieces have lower mean value of strength. If the cross sections increase, the behavior depends on the stress-strain law; if material is brittle, a larger cross section has the same effect as a greater length; plastic materials exhibit constant mean value of strength. Minimum strength values in practice vary but little with size of structural parts. The treatment (theoretical) is based upon the use of probability distributions of the strength. The paper contains some interesting and useful concepts, but further experimental evidence is needed to confirm the theory.

From author's summary by J. J. Brandstatter, USA

2534. Gatto, F., Some considerations on a new damping effect (in Italian), *Atti Conv. Internaz. Ultracust.* **1950,** 203–211, 1951.

Present work discusses two anelastic phenomena: (a) deformation increasing slowly with time, (b) deformation of an almost instantaneous character. The latter type is the principal concern of the paper and is defined as a tangential slip along planes where the mean value of the shear stress is larger than the corresponding cohesive stress of the material. This displacement is presumed to propagate with a velocity comparable to that of elastic shear waves. The analysis is a statistical one. It is assumed that, for this type, displacements may take place with equal probability along certain planes and that this probability follows a normal distribution. This, together with an assumed expression for the energy dissipation, leads to damping which is independent of the frequency of vibration of the specimen. Experimental verification is currently being sought.

E. Saibel, USA

2535. Van Nieuwkoop, J., A simple method for the nondestructive testing of defects in materials (in Dutch), *Metallen* **7,** 15, 247–254, Aug. 1952.

Various methods of nondestructive testing for tracing defects are reviewed, so far as this can be carried out by means of apparatus of simple design and the cost of which is not prohibitive. Further, a short description is given of the methods applied for tracing defects which require special apparatus.

From author's summary by M. A. Meyer, South Africa

2536. Bastien, P., Popoff, A., and Azou, P., Localized deformations in simple tension and their role in the formation of necking (in French), *Rev. Métall.* **49,** 11, 783–790, Nov. 1952.

Authors studied experimentally the origin of localized deformations in simple tension and their influence on the necking phenomenon. They observed that necking occurred always before the maximum load had been attained. Some homogeneous deformation continues after the maximum load has been attained. Materials tested (annealed): Ferrite (C = 0.08%), Cu, Al (99.97%), Mg (99.95%). A. Phillips, USA

Mechanical Properties of Specific Materials

(See also Revs. 2504, 2521, 2525, 2526, 2528, 2529, 2532, 2536, 2620)

2537. Stewart, W. C., and Schreitz, W. G., Thermal shock and other comparison tests of austenitic and ferritic steels for main steam piping, Ann. Meet. ASME, New York, Dec. 1952. Paper 52—A–35, 15 pp., 29 figs.

Superiority of strength properties of austenitic steels at high temperatures suggests the possibility of their use in steam lines—e.g., in naval vessels. Authors describe tests designed to compare behavior of austenitic and ferritic steels under service conditions. Tests were of two types, simulating conditions considered likely to cause failure in steam lines: Thermal shock, and cyclic deflections. Assemblies of standard pipes and valves of various types, employing a variety of welds, were used.

Thermal shock here refers to quenching action of boiler water carry-over. Large tensile stresses may be set up in inner surfaces of pipes as a result. Six tests were made, the shock being repeated 100 or more times in each test. Conduct of tests and results are reported in great detail, including steam pressures, temperature distributions, metallurgical information, formation of welds, etc. No failures resulted, but a tendency to form cracks in the welds was noted. This was more pronounced in the austenitic welds.

Cyclic deflection tests were intended to reproduce effects of periodically bringing steam piping up to temperature over a number of years. Mock-up thermal expansion bends were used. Bending deflections designed to induce higher than allowable stresses were imposed. Magnitude and range of stresses were increased until failure. Failures were of fatigue type.

Laboratory test program, also described in detail, includes control tests in tension, creep, stress rupture, and fatigue. Specimens were of material and treatment identical to those used in all parts of main tests.

Paper is primarily a report on tests conducted, with no attempt made to reach conclusions. Usefulness is somewhat impaired, in reviewer's opinion, by poor organization of the voluminous data. Many details unexplained in this paper become clear when previous paper by the authors [*Trans. ASME* **72,** 7, 1043–1060, Oct. 1950] is studied. Large number of tables, graphs, and photographs supplement the report. C. Richards, USA

2538. Ferguson, P. M., Ultimate strength design for reinforced concrete—why? *Univ. Texas, Proc. Texas struct. Engng. Conf.*, 72–93, Mar. 1952. $3.

Author urges that the straight-line working stress theory of reinforced-concrete design, on which present-day specifications are based, should be abandoned in favor of an ultimate strength theory. The straight-line theory seriously underestimates the compression load-carrying capacity of the concrete in beams and slabs. Procedure advocated in paper would lead to more economical use of both steel and concrete. P. C. Dunne, England

THE FOLLOWING PAPERS (REVS. 2539–2551) WERE PUBLISHED IN *Trans. Fourth Congr. Inter. Comm. Large Dams,* New Delhi, Jan. 1951, 4 vols. $48 per set.

2539. Campus, F., Concrete for large dams (in French), vol. III, 81–92.

In Belgium, three standard categories of cements containing granulated basic blast-furnace slag are used for large concrete dams. They are called: blast-furnace cement, permetallurgical cement, and supersulphated cement. The results of an important series of tests, beginning in 1934, are briefly related. They concern shrinkage, heat development, permeability, and the ultimate stresses, up to times of eleven years, of mortars and concrete stored in various conditions (drinking water, sea water, and sulphated water).

For the erection of the latest large dam built in Belgium, use has been made, for the first time in Europe, of concrete with large aggregates (up to 150 mm) containing permetallurgical cement. It has been compacted by vibration. Preliminary tests are related, as well as others concerning concrete of high compactness containing pebbles as large as 200 mm.

A new process of wet milling of granulated slag has been initiated in Belgium. Already used for the construction of a large dam in France, its latest development opens new prospects for the use of metallurgical cements. From author's summary

2540. **Fritsch, J., Use of trass in the construction of Austrian dams** (in French), vol. III, 93–104.

During the year 1949, trass cement was used in Austria for the construction of two arch dams. The present paper points out the methods and the implements used for the testing of trass concrete. It describes a new method in testing which shows, in addition to the usual method of testing the compressive strength and other similar matters, the reaction of fresh concrete during the vibration period. From author's summary

2541. **Vuorinen, J., Some tests on the effect of air-entrainment on the tensile strength and watertightness of concrete by making use of the splitting test method,** vol. III, 109–122.

The splitting-test method consists of loading the specimen by two narrow strips placed parallel at the opposite sides of the specimen. The rupture is a splitting failure when the tensile strength of the material is exceeded. Best results are obtained using a diametrally compressed cylinder or a cube with centrally placed strips.

The acceptance of the splitting test for determining the tensile strength and watertightness of concrete would suggest the possibility that these properties as well as the compressive strength could be determined, using the same type of test specimen in each case, without the necessity of preparing specimens especially for each of these purposes. From author's summary

2542. **Steele, B. W., Concrete for large dams,** vol. III, 155–187.

Progress is being made in the elimination of objectionable cracking in concrete work of all kinds, and especially the major cracks in the concrete of massive gravity structures. The use of air entrainment, low cement content per cu yd, and the placing of the mixed concrete at not in excess of 50 F during all seasons of the year will produce mass concrete that is relatively free of major cracks.

Low cement content for the interior of a dam, providing the mix is properly designed and placed, is second only to refrigeration in accomplishing a beneficial trend in the elimination of volume change due to excess heat. Mass concrete with a low cement content can be satisfactorily placed and consolidated, providing such lean concrete mixtures are properly designed and the aggregates are so processed as to produce uniform, well-graded material. From author's summary

2543. **Blanks, R. F., Meissner, H. S., and Cordon, W. A., The properties of mass concrete made with combinations of Portland Pozzolan-cement, as used by the Bureau of Reclamation,** vol. III, 199–214.

Portland ash pozzolan cement will produce favorable characteristics in concrete for mass construction. These include low temperature rise and slow rates of heat generation, high tensile strength and resistance to cracking, satisfactory compressive strengths which at late ages compare to similar concrete made with straight Portland cement, good resistance to dissolution by percolating water, and high impermeability. Many pozzolans have been found to reduce expansion often resulting from reaction between aggregate and cement high in alkalies. Concrete containing pozzolan possesses outstanding workability and is remarkably free of bleeding or water gain; this is particularly true of fly-ash pozzolan.

Many pozzolans may be obtained at the dam site at a much lower cost than Portland cement. Since they will replace much Portland cement in the concrete, considerable monetary savings are to be realized when pozzolans can be used.

From authors' summary

2544. **L'Hermite, R., Shrinkage and spontaneous cracking of cement and concrete** (in French), vol. III, 231–247.

Paper treats three related problems: (1) Shrinkage of set cement paste; (2) time to rupture of a set cement-paste ring shrinking around a rigid core; (3) stress conditions in and around reinforcing bars in concrete. At atmospheric humidities greater than 50%, the shrinkage of a specimen is assumed to be related to loss of weight, which is taken as equal to the loss of evaporable water. A mathematical expression is obtained for the average shrinkage in terms of the evaporable water, the humidity of storage, time, and a parameter dependent on the dimensions of the test piece.

It is proposed that the time to rupture of a cement-paste ring shrinking around a rigid core would provide a criterion for judging which cements are likely to give concretes which have a high shrinkage. F. A. Blakey, Australia

2545. **Rao, K. L., and Venkataraman, A. R., Surki as an admixture** (in French), vol. III, pp. 335–354.

It has been a common practice in India from very early times to add surki to lime mortars to insure durability and complete hardening. The effects of surki admixture on cement and lime mortar on important properties like shrinkage, permeability, and strength are studied. From authors' summary

2546. **Mary, M., and Chapelle, A., Use of wet ground slag cement in the construction of the Bort Dam** (in French), vol. III, 387–409.

2547. **Berthier, R.-M., Freezing in concrete** (in French), vol. III, 519–537.

The heterogeneous composition of concrete is the essential factor which determines its stability when exposed to freezing, which may cause deterioration by a process that is comparable to that which is seen in natural rock formation. This process is generally rather slow. Freezing may also cause rapid deterioration in the yielding structure of the concrete.

It has been determined that cement that has been altered by freezing can be restored to its normal characteristics, if the freezing is interrupted before complete deterioration.

The hardening of concrete and its resistance when exposed to freezing are greatly increased if it hardens under permanent load. Concrete deterioration due to freezing can be prevented by controlling the cement composition, by the correct design of the structures, and by careful supervision of construction methods.

From author's summary

2548. **Kallauner, O., Jr., and Rosa, J., Experimental methods for the standardization in fixing the value of cement for the building of dams,** vol. III, 539–550.

To replace the present existing test of soundness by a test giving objective numerical values, a dilatometer with a watch indicator was constructed. This apparatus has proved very efficient in practice for its speed in carrying out tests, for its precision, and the simplicity of the apparatus itself, in contrast to the very intricate apparatus of Bauschinger, Guttman, Amsler, etc. The results attained by the dilatometer were fully certified by a whole row of tests, by which it was sufficiently proved that the application of this test of soundness of cement is most suitable.

From authors' summary

2549. **Jablonsky, A., The effect of huminous impurities on the properties of concrete** (in French), vol. III, 551–558.

2550. Horejsi, J., and Kelis, F., Experiments made on cements and concrete used in the construction of a gravity dam in Czechoslovakia (in French), vol. III, 567–577.

2551. Hull, G., Concrete for large dams, vol. III, 477–484.

2552. Turazza, G., Contribution to the calculation of large-diameter pipes made from precompressed reinforced concrete (in Italian), *G. Gen. civ.* **90,** 7/8, 415–433, July/Aug. 1952.

Precompression is realized by winding a prestressed steel wire on the concrete pipe. Longitudinal stresses during winding are derived by integrating the differential equation of radial deflection; numerical values of deflection, shearing force, and bending moments are calculated for six different stages of winding.

In evaluating transverse stresses, the effects of shrinkage and plastic deformation are considered; the loss of tension in the wire and the centripetal tension on the external concrete layer are obtained.

Reviewer remarks that the useful tables could have been more easily derived, by means of the principle of superposition, from other fundamental cases of load.

D. Gentiloni-Silverj, Italy

2553. Concrete calendar 1952 [Beton-Kalender], Vol. 41, Berlin, Wilhelm Ernst & Sohn, 1952, 1161 pp., 1006 figs., tables. Parts I and II. 16 DM.

2554. Abeles, P. W., The principles and practice of prestressed concrete, New York, Frederick Ungar Publ. Co., 112 pp. $3.75.

Book deals primarily with prestressed-concrete beams. Principles of prestressing and its history, various systems, analysis and design, research, and practical applications are discussed in 12 chapters. Special emphasis is placed on the design, which is illustrated by several examples.

Author points out various advantages of prestressed concrete as compared with the ordinary reinforced concrete. Among these he points out the absence of dangerous cracks, high resilience, and economy. In the sections dealing with design it is emphasized that the calculations should be carried out for three stages of loading: (1) At transfer of prestress; (2) at working loads; and (3) at ultimate. Formulas for stress conditions at stages (1) and (2) are based on the theory of elasticity, considering full cross section of the beam. Formulas for stage (3) consider inelasticity of concrete and are based on steel stresses equal to the ultimate tensile stress. Factors of safety and allowable stresses are discussed in connection with the design formulas.

The book seems to be aimed at the practicing engineer. By its emphasis on the behavior of beams when loaded, the author gives the designer considerably more than just formulas to follow. The notes on research and a bibliography can serve a novice in the field as a good guide in his further studies. Numerous illustrations help to clarify the text. I. M. Viest, USA

2555. Chen, M. C., Ree, T., and Eyring, H., Stress relaxation and shrinkage in fibers, *Textile Res. J.* **32,** 6, 416–423, June 1952.

The relaxation of stress at constant strain in Saran (polyvinylidene chloride) fibers was measured with the fibers in air and in water. The temperature was varied between 20–67 C. The loss in weight during shrinkage was determined. The authors assume that this results from the squeezing-out of the plasticizer by the forces set up. The experimental results on stress relaxation are accounted for in terms of two types of Maxwell elements, and the heats of activation and the activation entropies of the two processes were determined. H. Kolsky, England

2556. Platt, M. M., Klein, W. G., and Hamburger, W. J., The applied mechanics of yarn structures as influenced by yarn geometry and inherent fiber properties, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 291–300, 1952.

In previous work, Platt [*Textile Res. J.* **20,** 1, 1950] applied stress analysis to prediction of yarn behavior under certain simplifying assumptions. Now one restriction, that the constituent fibers possess the same properties, is removed by assuming that breaking strength and elongation are normally distributed about their mean values. The predicted effect of this nonuniformity is to decrease the yarn strength to values as low as one third that for yarn made from uniform fibers. The theory checks well with experiments on cordage fibers and on cotton. [See also AMR **6,** Rev. 1914.]

D. J. Montgomery, USA

2557. Gerritsma, J., Theoretical considerations in analysis of logbook data (in Dutch), *Schip en Werf* **19,** 23, 507–517, Nov. 1952.

Statistical relations are deduced and applied to the analysis of logbook data with the aim of ascertaining the power in the service condition from model tank data. H. W. Lerbs, USA

Mechanics of Forming and Cutting

(See also Rev. 2518)

2558. Schaller, G. S., Engineering manufacturing methods, New York, London, Toronto; McGraw-Hill Book Co., Inc., 1953, ix + 613 pp. $7.

A presentation of present-day manufacturing processes and equipment, including machine tools and tooling. Primarily intended for students, it is also useful for designers and development engineers. Fundamentals are covered sufficiently to evaluate one type of manufacture against another with regard to the various casting and forming processes, methods of machining, tools and tool materials, welding, and brazing.

A. O. Schmidt, USA

2559. Lewis, K. G., and Milne, W., Machining—theory and practice, *Machinery, Lond.* **81,** 2087, 2091; 1050–1056, 1231–1236, 1247; Nov. 14, Dec. 12, 1952.

Authors present second and third in a series of articles [see AMR **6,** Rev. 1924] surveying developments in metal cutting highlighted by the 1950 ASM symposium of the same title. Tool geometry, heat developed in metal cutting, surface temperatures, essential characteristics of tool materials including hot hardness, toughness, and wear resistance, high-speed metal cutting and hot machining are discussed. Authors supplement material obtained from symposium with pertinent references to experimental work by British scientists.

H. R. Letner, USA

2560. Simonds, H. R., Weith, A. J., and Schack, W., Extrusion of plastics, rubber and metals, New York, Reinhold Publ. Corp., 1952, vii + 454 pp. $10.

Book gives a good fundamental approach to the preparation of plastics for extrusion and describes some of the extrusion processes as applied to plastics. The book covers schematic designs of several types of extrusion presses for extruding plastics. The discussion dealing with the extrusion of rubber is much less comprehensive, and the work on the extrusion of metals is very brief and only descriptive, dealing with generalities in a limited field. The brief description on the extrusion of miscellaneous materials

such as carbon, graphite for lead pencils, ceramic materials, and others is generally informative. R. G. Sturm, USA

2561. **Sieber, K., Developments in cold-flow pressing and extrusion of steel,** *Machinery, Lond.* **80, 2062, 891–897,** May 1952.

The theory of cold-forming operations of such types as rod and tube drawing, rod-shaped extrusion, and tubular extrusion is discussed, and semi-empirical formulas are presented for predicting pressures required. The factors considered are: (1) Mean formability, the average true stress value over the range of forming deformation obtained from a true-stress true-strain diagram; (2) over-all change in configuration; and (3) the effect of friction.

The method consists of expressing the force required under ideal conditions to change the configuration and to add an empirical term to correct for the effects of friction.

W. Schroeder, USA

2562. **Artobolevskiĭ, S. I., On the question of productivity of machine tools** (in Russian), *Trudi Sem. teor. Mash. Mekh.* **9,** 43, 13–49, 1951.

Hydraulics; Cavitation; Transport

(See also Revs. 2435, 2458, 2496, 2497, 2498, 2499, 2500, 2501, 2503, 2505, 2506, 2507, 2508)

2563. **Rousselier, M., and Blanchet, P., Some realizations of syphons** (in French), *Trans. Fourth Congr. Inter. Comm. Large Dams,* New Delhi, Jan. 1951, in 4 vols, vol. IV, 413–418. $48 per set.

2564. **Macagno, E. O., Experimental study of hydraulic failure of granular masses** (in Spanish), *Univ. nac. La Plata, Publ. Fac. Cienc. Fisicomat.* (2) **4,** 4, 395–452, Dec. 1951.

A discussion of some 90 experiments to determine mechanism of expansion and eventual rupture of granular beds by water. Author ignores recent contributions in this country by Fair and Hatch, who have related significant parameters pertaining to flow through sand filters. No mention is made of literature on fluidized beds. Author overlooks that the flow patterns developed by him have been discussed by Slichter and Muskat in detail. J. M. DallaValle, USA

2565. **Stommel, H., and Farmer, H. G., Abrupt change in width in two-layer open channel flow,** *J. mar. Res.* **11,** 2, 205–214, 1952.

Recalling that a long wave of infinitesimal amplitude is stationary when the Froude number $F = u^2/gD = 1$ (u velocity, D depth), and that this occurs in any channel transition which acts as a control, authors conjecture that a transition may be expected to act as a control on the level of the interface between the two layers of a two-layer flow when a long wave on this interface is stationary. A condition for such a wave to be stationary is derived in terms of an interfacial Froude number $F_i = u_1^2\rho_2/gD_1(\rho_2 - \rho_1)$ (ρ density, subscripts 1 and 2 refer to upper and lower layer, respectively). The theory is compared with experimental results and data for the Mississippi River, showing reasonable agreement.

Measurements for an abrupt contraction, when the latter does not act as a control, indicate negligible energy loss in the transition. G. W. Morgan, USA

Incompressible Flow: Laminar; Viscous

2566. **Vandrey, F., Graphical solution of Multhopp's equations for the lift distribution of wings,** *Aero. Res. Counc. Lond. curr. Pap.* **96,** 8 pp., 1952.

The Multhopp method for determining the lift distribution of wings is facilitated by a graphical procedure. The values of the unknown circulations are represented by scales. The multiplication of these values and the constant coefficients of the equations are effected by auxiliary scales in the diagrams. The corrections of the approximate values are transferred from the auxiliary scales to the main scales by a pair of dividers. G. E. Nitzberg, USA

2567. **Endô, D., Problems of two flat plates in hydrodynamics** (in Japanese), *Studies math. Phys.* **2,** 1–65, June 1952. Iwanami Shoten Publ., Tokyo.

Uniform flow of a nonviscous incompressible fluid past two flat plates of arbitrary lengths and of arbitrary relative orientation is considered by means of the conformal mapping of the physical plane onto the region between two concentric circles. In the first part (pp. 1–23), exact expressions are obtained for the resultant forces acting on the two plates. In the second part (pp. 25–36), expressions for the resultant moment on each of the two plates are obtained in two forms, one in a closed form in terms of elliptic functions, and the other in an infinite series of trigonometric functions. In the third part (pp. 37–65), detailed procedures of numerical calculations are explained and the results for the lift, drag, and moment for various combinations of two plates are given in tables and graphs. I. Imai, Japan

2568. **Tasiro, Y., On the solution of the flow with free streamlines** (in Japanese), *Studies math. Phys.* **2,** 189–219, June 1952. Iwanami Shoten Publ., Tokyo.

Unified treatment by the hodograph method is given to various cases of two-dimensional incompressible flow bounded by straight fixed walls and free streamlines. The cases treated are that of an infinite stream as well as a free jet of a finite and semi-infinite width past a flat plate and bent flat plate (generalization of Bobyleff's problem) and of a free jet issuing from a nozzle fitted with a valve. Some numerical results are given for the case of a bent flat plate in an infinite stream. I. Imai, Japan

2569. **Prakash, P., General steady flow superposable on a constant velocity,** *Ganita* **3,** 2, 91–93, Dec. 1952.

Starting from the condition of superposability given by R. Ballabh [*Proc. Benaras math. Soc., N.S.* 71, 1940], author finds the class of flow which can be superposed on a uniform flow to yield another possible flow. C.-S. Yih, USA

2570. **Combes, G., and Borot, R., New graph for the calculation of air reservoirs, account being taken of the head losses** (in French), *Houille blanche* **7,** 5, 723–729, Oct.–Nov. 1952.

Liquid is pumped along a horizontal pipe against a constant head at the far end. Head loss in pipe is assumed equal to αw^2, where w is speed of flow. Near pump is an air reservoir. If pump suddenly stops, there is a surge reduction in pressure followed by a surge increase, latter being greater. Over-pressure is supposed limited by a "one-way" diaphram or a one-way valve with a hole which brings total head loss to βw^2. Nomograms are given to determine volume of air required in reservoir and value of β when maximum permissible underpressure and overpressure are known. Nomograms are simple to use and interpolation between curves reasonably easy.

J. C. Cooke, British Malaya

2571. Kronig, R., and Thellung, A., On the hydrodynamics of non-viscous fluids and the theory of helium II, *Physica* **18,** 749–761, 1952.

2572. Serrin, J., Two hydrodynamic comparison theorems, *J. rational Mech. Analysis* **1,** 563–572, 1952.

2573. Dolapchiev, B., Generalized procedure for the stability analysis of arbitrarily arranged vortex streets (in Bulgarian, with German summary), *Godishnik, Univ. Sofia, Fac. Sci. Livre* **1,** 46, 369–376, 1950.

See AMR **4,** Rev. 4199.

2574. Wendt, H., The problem of a submerged spherical source (in German), *ZAMM* **32,** 11/12, 338–358, Nov./Dec. 1952.

The influence of a submerged spherical source on the shape of the surface of an infinitely extended ocean is calculated. The fluid is assumed to be incompressible and nonviscous, while the flow is supposed to be irrotational. The solution is given by successive approximations and is obtained as a power series in the depth under the surface and the productivity of the source.

H. C. Brinkman, Indonesia

2575. Dorfman, L. A., Calculation of vortexless flow around airfoil cascades and construction of cascades from given velocity distribution on the airfoils (in Russian), *Prikl. Mat. Mekh.* **16,** 5, 599–612, Sept./Oct. 1952.

Investigation deals with the harmonic function $S(\xi, \eta) + iT(\xi, \eta)$ corresponding to potential flow conditions along an infinite straight cascade of straight vanes. Relations between the components of the function are analyzed. The flow along a cascade of arbitrary vanes is studied by means of a conformal transformation which maps the exterior of the cascade on the exterior of a cascade of straight vanes. Numerical analysis uses the method of successive approximations. On the basis of the established relations between the two corresponding flows, the velocity distribution on the surface of the vanes may be deduced. Attention is concentrated on two problems: (1) Evaluating the flow of a given cascade; (2) improvement of the vane profile of a cascade on the basis of a presumed velocity distribution for the vanes.

Remarks of reviewer: As far as the needs of the engineer are concerned, the determination of the vane profile by the well-known singularity method seems to be much more advantageous than the method developed in the paper. It might be mentioned also that the latter approach permits direct extension of procedures to three-dimensional considerations.

M. Strscheletzky, Germany

2576. Sauer, R., Subsonic flow around airfoils for quadratically approximated adiabatic line (in German), *S. B. math.-nat. Kl. bay. Akad. Wiss., München,* 1951, 65–71, 1952.

Author gives an extension of Kármán-Tsien's method for dealing with the two-dimensional subsonic flow. The essential point of this method lies in reducing the fundamental equation in the hodograph plane to Laplace's equation. To do this, the hodograph equation for the stream function ψ is transformed to the normal form

$$\psi_{\omega\omega}^* + \psi_{\vartheta\vartheta}^* + 4F(\omega)\psi^* = 0,\ 4F = H(d/d\omega)(H^{-2}(dH/d\omega))$$

where $\omega = \int (1 - M^2)^{1/2} w^{-1} dw,\ \psi = H(\omega)\psi^*,$

$$H^2 = \rho(1 - M^2)^{1/2}$$

and w, ϑ, M, ρ are, respectively, the magnitude and the direction angle of the velocity vector, the local Mach number, and the density. When $H = \text{const}$ or $H^{-2}(dH/d\omega) = \text{const}$, the above equation reduces to Laplace's equation. The former corresponds to the well-known von Kármán-Tsien hypothetical gas, while the latter defines a new hypothetical gas. This hypothetical gas is found to have a pressure-density relation with three parameters (in contrast to two parameters in Kármán-Tsien's gas), and a quadratic approximation is possible up to the curvature of the adiabatic pressure-density relation.

An alternative but essentially identical method is also proposed in which, instead of the stream function, Legendre's potential is used. No numerical computations are given.

S. Tomotika, Japan

2577. Kronauer, R. E., Secondary flow in fluid dynamics, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 747–756, 1952.

The paper describes an iterative method of solving for secondary flows arising from nonviscous, rotational flow around objects and through curved channels. The method starts with an assumed velocity field. A vortex field is then constructed using Cauchy's vorticity equations, in which the displacement derivatives are obtained from the assumed velocity field. The vortex field can then be integrated to give a new velocity field (second approximation), and the procedure repeated until the solution converges.

Author states that the labor involved in each step of iteration is so great as to prohibit more than a single step at this time. However, a realistic selection of the initial assumed velocity distribution can result in a second approximation for the velocity distribution that contains much valuable information about secondary flows. For a cascade of symmetrical airfoils, results of the method compare favorably (in the plane of symmetry between airfoils) with experimental results. Author devotes considerable space to discussions of the physical mechanisms involved.

J. D. Stanitz, USA

2578. van de Vooren, A. I., The generalization of Prandtl's equation for yawed and swept wings, *Nat. LuchtLab. Amsterdam Rap.* F.121, 24 pp., Dec. 1952.

Using lifting-surface theory, the author derives an expansion for the downwash in terms of inverse powers of the aspect ratio. Neglecting second- and higher-order powers, a simple expression is obtained for the downwash which is valid for large values of the aspect ratio. It is shown that the change in downwash due to three-dimensional flow is not constant along the chord for a yawed or sweptback wing, there being an induced camber effect.

A. W. Babister, Scotland

Compressible Flow, Gas Dynamics

(See also Revs. 2395, 2576, 2600, 2604, 2616, 2619, 2629, 2642)

2579. Oswatitsch, K., Gas dynamics [**Gasdynamik**], Wien, Springer-Verlag, 1952, xiii + 456 pp., 300 figs., 3 tables. $18.60.

An original and thorough reference book on the subject of the motion of compressible media. Excluded are problems which would fall under the kinetic theory of gases. The case of heat addition is treated only in the simplest cases, and the effects of friction are taken up in one brief chapter toward the end. The major portion of the book is devoted to nonviscous compressible problems between the bounds of meteorology on one hand and acoustics on the other. The former limit is achieved by neglecting Coriolis effects completely and gravity effects in most cases; the latter limit is clearly defined except for the connection of propagation of waves of finite amplitude and the field of

flutter, which is briefly mentioned under similarity considerations.

The scope of the text is best given by the contents of the chapters. Chap. I gives a review of the thermodynamics of a particle. The one-dimensional (or hydraulic) theory is developed in chap. II for steady flow and in chap. III for unsteady flow, including propagation of cylindrical and spherical waves. The extension to the most general equations is made in chap. IV. These are given first in integral form which, therefore, includes the case of shocks. The differential form of the fundamental equations is then obtained, followed by a discussion of shocks, similarity laws, vorticity, and some spherical topics. Application of the integral laws are given in chap. V and include such problems as jet contraction and deflection, cascade nozzle thrust, and several jet propulsion topics. Chap. VI gives the basic equations and special exact solutions for steady flows. These solutions apply equally well to the special problems of steady two-dimensional and axisymmetrical subsonic flow (chap. VII), steady two-dimensional and axisymmetric supersonic flow (VIII), and steady transonic flow (IX). An equally close connection exists between the steady, two-dimensional axisymmetric, supersonic problems (VIII) and the unsteady one-dimensional cases (III). The two-dimensional unsteady flows and the three-dimensional steady supersonic flows are similarly related. Problems which usually assume small perturbations are taken up in chap. X entitled "Special steady and unsteady three-dimensional flows." This includes, for instance, conical flows and finite wings. The effect of friction is summarized in chap. XI, and chap. XII gives a review of experimental techniques and analogies. Isentropic tables and nomograms, characteristic and shock polar diagrams, and a table of useful integrals and integral equations are given at the end of the book.

Presentation favors a clear statement of the technical and physical problems instead of the mathematical aspects. Not all methods of solution are given, and the author's preference for the method of characteristics is evident. The typical examples and occasional comparisons with the experiments are well chosen.

H. P. Liepman, USA

©2580. **Rosenhead, L., Nicholson, L. F., Bickley, W. G., Thornhill, C. K., Jones, C. W., Thomlinson, R. C., A selection of tables for use in calculations of compressible airflow,** Oxford, Clarendon Press, 1952, viii + 143 pp. $8.

Tables are designed for reduction of data or computation of steady one- or two-dimensional compressible airflows. Choice of arguments, intervals, and presentation of differences reflect effort to make tables directly and easily usable. Format and printing are excellent.

Values are given to five significant figures or at least to five places with accuracy of one or better in last place. As a product of well-known experts in field of table preparation, volume should contain a minimum of errors. A summary of the contents includes:

I Isentropic flow tables. Gas properties and important functions such as Mach number cross-sectional area, max pressure coefficient, thrust coefficient, and dynamic pressure are given for the arguments Mach no. (0 to 5), specific speed (fluid vel/fluid vel at M = 1), (0 to 2.44) and the ratio fluid vel/max fluid vel (0 to 1.0).

II Characteristic tables. The gas properties and some important functions are tabulated versus deflection angle and Mach angle. Special function for Prandtl-Meyer flows is included.

III Shock tables. Ratios of gas properties and stagnation properties up and downstream of a normal shock are given for the arguments upstream Mach no. (1 to 5) and upstream specific speed (1 to 2.44). For oblique shocks, the maximum deflection angle and the deflection angle to yield $M_2 = 1$ are tabulated for upstream Mach no. M (1 to 20).

IV Tables for the reduction of pressure ratios. In separate tables, upstream Mach no. is given for the arguments (static pressure/total pressure), (static/Pitot pressure) and (Pitot/total pressure). The ranges of Mach no. are (0 to 5.566), (1 to 5.05), and (1 to 5.983).

V Tables of powers of x and $(1 - x^2)$. Powers are those commonly encountered in formulas for compressible air flow.

VI Miscellaneous tables. These include tables for (a) computation of Reynolds numbers, (b) giving relationship between pressure coefficients for incompressible and compressible flow, (c) derivatives of various flow functions with respect to γ, (d) speed of sound as function of temperature, (e) standard atmosphere, and (f) summary tables of isentropic flow and shock relations.

Some additional functions, such as those connected with flow over cones and wedges, will be presented on graphs and charts in a forthcoming volume. A. St. John, USA

2581. Graham, E. W., Solution of a non-linear equation for transonic flow with rotational symmetry, *Douglas Aircr. Co., Rep.* SM-13677, 24 pp., 1949.

The steady compressible flow about a body consisting of a semi-infinite circular cylinder followed by a boattail of circular cross section is investigated. The free stream is assumed to be flowing parallel to the body axis at Mach number unity. The transonic approximation to the potential equation for steady compressible flow with axial symmetry is reduced to an infinite set of ordinary differential equations by a series expansion. By assuming certain relations between the coefficients of the series expansion, a subclass of solutions of the transonic potential equation with convenient analytic properties is obtained. A method for approximating the flow about a given boattail by suitable combinations of solutions of the special type noted above is indicated. Calculations are carried out for configurations, and the results are compared with the corresponding Prandtl-Meyer solutions for two-dimensional flow.

The method of solution employed in the analysis appears to be applicable to a wide range of problems.

H. R. Lawrence, USA

2582. Tamada, K., On the two-dimensional flow of a hypothetical gas which obeys the adiabatic law approximately, with special reference to Taylor's problem (in Japanese), *Studies math. Phys.* 2, 107–124, June 1952. Iwanami Shoten Publ., Tokyo.

Essentially the same as S. Tomotika and K. Tamada, "Studies on two-dimensional transonic flow of compressible fluid," part III [AMR 4, Rev. 3936]. I. Imai, Japan

2583. Gamble, H. E., Some effects of Reynolds number on a cambered wing at high subsonic Mach numbers, *Aero. Res. Counc. Lond. curr. Pap.* 103, 13 pp., 23 figs., May 1951, published 1952.

An untapered, sweptback wing of aspect ratio 4, sweepback 25°, and section 12% thick (RAE 104 with 1% camber, $a = 0.6$) was tested in the RAE high-speed tunnel. The pressure distribution was measured at the mid-semispan section at various Mach numbers up to 0.88 at Reynolds numbers of 0.8, 1.8, and 3.5×10^6.

Pressure distributions at the three Reynolds numbers are rather different, although the boundary layer was laminar back to about 70% of the chord in all cases. At the highest Reynolds number, the suctions on upper surface at high Mach numbers increase

from leading edge of wing right up to about 50% or 60% of chord, while at lowest Reynolds number they remain almost constant from about 30% to about 60% of the chord. This flat-topped pressure distribution, which is associated with a λ-type shock wave, results in lower lift coefficients and higher pitching moment coefficients than those obtained at higher Reynolds numbers. From author's summary

2584. Inoue, N., A new mechanical analogy for the flow of compressible fluid, *J. aero Sci.* **19,** 11, 783–784, Nov. 1952.

The analogy between the stress plane in statically determinate plane plastic flow and the hodograph plane in two-dimensional irrotational compressible flow is developed. This had been done previously by H. Geiringer [AMR **4,** Rev. 3546]. Slip lines map into Mach lines and isostatics into equipotentials and streamlines. For the analog of Bernoulli's equation to hold, a second-order differential equation must be satisfied by the yield function. A suitable solution can be found which agrees closely with the von Mises yield criterion. There are several misprints. A. F. Pillow, Australia

2585. Pai, S. I., The laminar jet mixing of two compressible fluids, Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 297–307, 1952. $6.

The equations of motion, energy, and diffusion for steady two-dimensional flow are developed by means of the von Mises transformation (i.e., in terms of x and ψ), using the usual assumptions of boundary-layer theory, and it is suggested that solutions can be obtained numerically in steps by a finite difference method. Reviewer notes that all three equations involve double differentiations, but the use of a modern high-speed computing machine may help to insure adequate accuracy. The results for two simple examples are presented; one is concerned with the isothermal mixing of two uniform streams of air and CO_2, and the other is concerned with the isothermal mixing of a jet of CO_2 emerging into a stream of air. The more rapid spread of mass than of velocity in both cases is noted.

A. D. Young, England

Turbulence, Boundary Layer, etc.

(See also Rev. 2631)

2586. Thwaites, B., On the flow past a flat plate with uniform suction, *Aero. Res. Counc. Lond. Rep. Mem.* 2481, 11 pp., 1946, published 1952.

A new method of performing boundary-layer calculations is introduced in this paper, and is applied to the problem of finding the characteristics of uniform flow past a flat plate through which there is a constant normal velocity. An exact solution to this problem has not yet been found and it is, therefore, difficult to assess the accuracy of the results obtained. The results, however, are compared with those of AMR **2,** Rev. 355, and *Luftfahrtforschung* **19,** 9, pp. 293–301, 1942. R.T.P. transl. 1753; *Aero. Res. Counc.* 6634, Apr. 1943; H. Schlichting, "The boundary layer of the flat plate under condition of suction and air injection." The new method will be applied to other problems and is explained in detail in *Rep. Mem.* 2587 [AMR **6,** Rev. 584].

When the momentum equation is being used, one obvious advantage of the method is that, in "adding" velocity profiles, the momentum thickness of each may be added to give momentum thickness of the whole. This is not so in the usual methods of boundary-layer calculations, and great simplification is thereby obtained.

From author's summary by G. R. Graetzer, USA

2587. Wijker, H., Survey of transition point measurements at the N.L.L., mainly for two-dimensional flow over a N.A.C.A. 0018 profile, *Nat. LuchtLab. Amsterdam Reap.* A.1269, 14 pp., 1951.

Article discusses the following methods for measuring the transition point: china clay, liquid film, H_2S, smoke, total head tube, turbulence level, transition wire, and stethoscope. The transition points measured by a number of these methods in a turbulent wind tunnel are compared with one another and with measurements at the NACA. The measurements were made for angles of attack between $-6°$ and $+10°$ and for Reynolds numbers between 0.4×10^6 and 2.9×10^6.

N. Tetervin, USA

2588. Shibuya, I., Theoretical study of turbulent transition of a rotating circular disc, *Rep. Inst. high Speed Mech., Tôhoku Univ.* **1,** 27–36, 1951.

The turbulent transition of a flow between a rotating circular disk and two parallel walls is investigated theoretically. Since the distances between them are assumed to be very small, the fluid viscosity may be effective all over the space, and two components of the disturbing velocity seem to be very important in causing flow transition, the other component normal to the disk being capable of neglect. The small vorticity of the turbulence may be transported from the center to the tip by the centrifugal force which appears by means of the viscosity effect between the wall or the disk and the fluid. Therefore, a disturbance appearing in a flow near the wall or disk may be accumulated near the tip, and damping effect due to the viscosity perhaps may be overcome by the accumulation of vorticities.

A momentum equation could be introduced by integrating the equation of motion with respect to z, which is taken in the direction normal to the disk surface, from the disk to the wall. In this case, one can consider two types of velocity distribution, and the critical values of Reynolds number corresponding to each case were found. The experimental values obtained by Schultz-Grunow and Y. Kitani are found between these two theoretical ones. From author's summary by C. C. Lin, USA

2589. Shibuya, I., One contribution to the statistical theory of turbulence, I, II, *Rep. Inst. high Speed Mech., Tôhoku Univ.* 2, 107–122, Mar. 1952.

In part I, the author expands the spectral expression of intensity of turbulence in a power series of x and takes the third term of this series as the triple correlation term. He then shows that the experiment of Simmons and Salter, which was used by G. I. Taylor to discuss the order of magnitude of the triple correlation term, is inadequate for such discussion.

In part II, the relation between λ^2 and $\overline{u'^2}$ is dealt with on the basis of a new assumption which seems to be identical with von Kármán's dynamical similarity theory.

From author's summary by S. I. Pai, USA

2590. Broszko, M., On the fundamental equations of turbulent motion of liquids (in French), *Bull. Acad. Polon. Sci. Lettres Cl. Sci. Mat. Nat. (A) Sci. Math.* **3–4,** 243–252, Mar.–Apr., 1951.

Author attempts to create a general turbulence theory. He begins with the Reynolds equations and defines averaging process in Reynolds manner. To derive additional equations interrelating mean and turbulent velocity components, author applies his previous theory (1946). Critical comments on derivation of this theory and consequences of additional equations were given by W. Squire [AMR **5,** Rev. 3176], who pointed out serious deficiencies of this theory as a complete rational theory of turbulent flow. Author applies his formulas to axisymmetric steady flow,

expresses turbulent components in terms of mean components, and compares so-calculated mean velocity distribution with tests by G.I. Taylor [*Proc. roy. Soc. Lond.* (*A*) **157,** 565, 1936] and by T. E. Stanton [*Proc. roy. Soc. Lond.* (*A*) **85,** 366, 1911]. In spite of its deficiencies, the theory gives satisfactory results for mean velocity distribution.

Reviewer points out two items: There is considerable artificialness in assumptions for additional equations (see also Squire); attempt to verify turbulent theory by expressing turbulent components in terms of mean components in steady flow is fundamentally wrong. Any mixing theory gives fair results from this standpoint. To verify theory, one has to compare results with tests of turbulent components.

M. Z. Krzywoblocki, USA

2591. **Proudman, I., The generation of sound by isotropic turbulence,** *Proc. roy. Soc. Lond.* (*A*) **214,** 1116, 119–132, Aug. 1952.

A finite region, with fixed boundaries, of an infinite expanse of compressible fluid is in turbulent motion. This motion generates noise and radiates it into the surrounding fluid, which is at rest apart from the usual small motions characteristic of sound. The acoustic properties of the system are studied in the special case in which the turbulent region consists of decaying statistically homogeneous and isotropic turbulence. It is assumed that the Reynolds number of the turbulence is large, and that the Mach number is small. The noise appears to be generated mainly by those eddies of the turbulence whose contribution to the rate of dissipation of kinetic energy by viscosity is negligible. It is shown, by combining a method which M. J. Lighthill developed in 1952 with techniques from the statistical theory of isotropic turbulence, that the intensity of sound at large distances from the turbulence is the same as that due to a volume distribution of simple acoustic sources occupying the turbulent region. In this analogy, the whole fluid is to be regarded as a stationary and uniform acoustic medium. The local value of the acoustic power output P per mass of turbulent fluid is given approximately by the formula

$$P = -(3/2)\alpha(d\overline{\tilde{u}^2}/dt)\,(\overline{\tilde{u}^2}/c^2)^{5/2}$$

with $\overline{\tilde{u}^2}$ the mean-square velocity fluctuation, t the time, c the velocity of sound, which is here assumed to be approximately uniform throughout the whole fluid. The constant α is expressed in terms of the well-known velocity correlation function by assuming the joint probability distribution of the turbulent velocities and their first two time-derivatives at two points. Its numerical value ~ 38 is obtained, corresponding to Heisenberg's theoretical spectrum of isotropic turbulence.

It is found that the effects of decay make only a small contribution to the value of α, and the order of magnitude of α is not changed when widely differing forms of the correlation function are used.

From author's summary by M. Schaefer, Germany

Aerodynamics of Flight; Wind Forces

(See also Revs. 2434, 2575, 2613)

2592. **Nilakantan, P., and Krishnamurthy, T. S., Take-off ground run of aeroplanes,** *J. aero. Soc. India* **4,** 4, 119–131, Nov. 1952.

A semi-empirical method estimates the ground run required under various conditions for an airplane of known characteristics whose ground run has been previously measured under at least one set of conditions. The basic relation used is (assuming ratio of take-off to stalling speed some fixed value)

$$S = K\,(W/P_{T.O.})\,(W/S)^{3/2}\,(1/\rho)^{3/2}$$

where ρ = density of air, W/S = wing loading, $W/P_{T.O.}$ = take-off power loading.

The factor K is empirically determined and is primarily a function of $C_{L_{max}}$, ratio of take-off to stalling speed, the ratio of wing-loading to power-loading, and the amount of interaction of the slipstream with the ground for the type of configuration being considered. From a mathematical and physical standpoint, the paper leaves much to be desired, but apparently the method can be used as a practical aid in actual airplane operations.

R. M. Stewart, USA

2593. **Millsaps, K., Aerodynamic damping of phugoids,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 37–41, 1952.

Author states his aim as the review and extension of work described by Krylov and Bogolyubov in "Contributions to the aerodynamic conference," p. 101, Moscow, 1935 (in Russian). Using the Lindstedt method [see H. Poincaré: "Les Méthodes Nouvelles de la Mécanique Céleste," **II,** Gauthier et fils, Paris, 1892], the nonlinear problem of the effects of aerodynamic drag on the phugoid motion of an aircraft is considered. Plots of the motion, obtained from an analog computer, are given for special cases, and it is shown from these that the method leads to motions which approximate true motions fairly well as long as aircraft is not in level flight. Since damping tends to produce level flight, the approximation is best during initial stages of motion. Reading of paper is made difficult by typographical errors, failure to define all symbols used, and application of unconventional notation.

M. Shinbrot, USA

2594. **Lyons, D. J., Investigations on stalling behaviour, rudder oscillations, take-off swing and flow round nacelles on the Tudor I aircraft,** *Aero. Res. Counc. Lond. Rep. Mem.* 2789, 18 pp., Dec. 1947, published 1952.

During the development of the Tudor I aircraft, the Royal Aircraft Establishment cooperated in the flight tests. This report summarizes the results, which are felt to be of general interest.

The importance of "deep tufting" in leading to an understanding of varied aerodynamic problems has again been forcibly demonstrated; namely, in showing that (a) early buffeting of the Tudor as the stall is approached was due to a very small air leak around the leading edge of the wing root, causing a breakaway of flow, the resultant wake of which hit the tailplane; (b) early wing-tip stalling was shown to be due to small malfitment of the T.K.S. deicers; (c) rudder "kicking" arose from flow through the hinge cutouts; (d) excessive take-off swing was due to poor rudder control as a result of the early rudder stall, and to the fact that the aircraft was stalled in the ground attitude; (e) the inner nacelle needed considerable lengthening.

From author's summary

2595. **Gray, W. E., and Davies, H., Note on the maintenance of laminar-flow wings,** *Aero. Res. Counc. Lond. Rep. Mem.* 2485, 3 pp., Apr. 1947, published 1952.

The maintenance of laminar-flow wings involves two problems: (1) The prevention of deterioration in the surface itself (e.g., cracking of the paint or filler, increase in roughness or waviness, etc., whether due to weathering, stresses in flight, or accidental damage); (2) the prevention of contamination of the surface with flies, etc.

This note gives an account of experience gained at the Royal Aircraft Establishment in dealing with these problems during flight tests on the characteristics of low-drag wings.

From authors' summary

2596. Küchemann, D., and Kettle, D. J., The effect of endplates on swept wings, *Aero. Res. Counc. Lond. curr. Pap.* 104, 11 pp., 12 figs., June 1951, published 1952.

Existing methods of calculating the effect of endplates on straight wings are modified so as to apply to swept wings. The changes in over-all lift and drag, and also the spanwise distribution of the additional load, can be calculated.

The theoretical results are compared with experimental results obtained on swept wings, including new measurements of lift, drag, and pitching moment made on an untapered 45° sweptback wing of aspect ratio 3 at low speed.

The method of calculation is also extended to cover the effect of the tip vortex which is formed on wings without endplates.

From authors' summary

2597. Keiller, I. L., The design of jettisonable cockpit hoods, *Aero. Res. Counc. Lond. curr. Pap.* 105, 22 pp., 9 figs., Sept. 1951, published 1952.

Consideration is given in this note to the jettisoning problems involved in the design of all types of hoods and cockpit covers. Certain basic design criteria are proposed and the various methods of meeting them are discussed. Recommendations on good design practice are given where possible. With the knowledge that is at present available, the design of a satisfactory orthodox hood should present no great problems, but the more advanced designs are likely to cause some difficulty.

From author's summary

2598. Batson, A. S., Preston, J. H., and Warsap, J. H., Experiments giving hinge moment and lift on a NACA 0015 aerofoil fitted with a 40 per cent control, with especial reference to effect of curvature of control surface, *Aero. Res. Counc. Lond. Rep. Mem.* 2698, 27 pp., 1943, published 1952.

Authors present results of an investigation made in 1943 on control-surface hinge moment and effectiveness. Paper includes the effects of control surface concavity and convexity. A linear relationship is established between a mean trailing-edge angle of the control surface and the slopes of the lift and hinge-moment data plotted against angle of attack and/or control surface deflection. R. M. Crane, USA

2599. Drescher, H., Investigation on a symmetrical airfoil of the effects of rapid movements of a flap with sealed gap (in German), *Mitt. Max-Planck-Inst. Strömungsforschung* no. 6, 71 pp., 1952.

This paper reports some of the results of experiments conducted in a water tunnel to investigate the transition processes which occur when a flap on an airfoil at fixed angle of attack is moved from an initial position to a final position with constant angular velocity. Angles of attack from $-15°$ to $+15°$ and flap angles from 0° to 60° are considered. In addition to quantitative results for the pressures and normal forces, over 200 flow photographs are included. J. R. Spreiter, USA

2600. Henderson, A., Jr., Supersonic wave drag of nonlifting delta wings with linearly varying thickness ratio, *NACA TN* 2858, 51 pp., Dec. 1952.

Von Kármán-Puckett's source-and-sink method is used. It is found that a delta wing of the type considered can have less drag than a constant-thickness-ratio delta wing of same plane form when both wings have either same projected frontal area or same internal volume.

From author's summary by P. Schwaar, Switzerland

2601. Hannah, Margery E., and Margolis, K., Span load distributions resulting from constant angle of attack, steady rolling velocity, steady pitching velocity, and constant vertical acceleration for tapered swept-back wings with streamwise tips, subsonic leading edges, and supersonic trailing edges, *NACA TN* 2831, 221 pp., Dec. 1952.

Linearized theory is used to calculate load distributions for motions described in title. Numerical results are presented in terms of design charts from which desired loading may be obtained for given values of aspect ratio, taper ratio, Mach number and leading-edge sweepback. 200 pages of charts are given.

K. C. Harder, USA

2602. Bretoi, R. N., Automatic flight control—analysis and synthesis of lateral-control problem, *Trans. ASME* **74,** 3, 415-427, Apr. 1952.

Paper presents a practical approach to the synthesis of automatic flight-control equipment associated with the lateral control of aircraft. The treatment employs, of necessity, the conventional cumbersome equations associated with the lateral stability problem; its value lies in the clear-cut and expeditious manner in which these equations are handled. Of particular engineering value is the procedure of first considering a simplified approximate version of the problem in which the effect of sideslip is neglected. This approximation permits a simple solution of the problem by elementary mathematics. Analog-computer solutions are employed to handle the complete equations of the later, more exact stage of the study.

The correlation with flight-test data is of particular significance; reasonably good correlation is indicated in the paper. Additional value is imparted to the paper by the inclusion of a numerical example involving the coefficients of a typical fighter aircraft. Author mentions the manner in which optimum controller adjustments change with flight condition, and suggests a scheduling of the autopilot parameters in accordance with such variables as Mach number and altitude.

Comments made by discussers should also interest readers. Discussion by B. G. Bromberg, in particular, adds many points of practical interest. Reviewer shares Bromberg's major criticism of paper in that it is felt that the techniques employed by the servomechanism engineer, including the use of block diagrams and the concept of transfer functions, could have been used to advantage. It should be acknowledged that the author did employ one of these techniques, as some of his data were presented in the form of frequency-response curves.

The paper is recommended reading for all concerned with the automatic control of aircraft. R. J. Kochenburger, USA

2603. Zhukovskiĭ, N. E., Collected works. The basic theory of aeronautics [Sobraniye sochineniĭ. Teoreticheskiye osnovi vozdukhoplavaniya], Moscow-Leningrad, Gosud. Izd. Tekh.-Teor. Lit., 1950, 623 pp.

This volume VI of the collected works by N. E. Zhukovskiĭ comprises a series of lectures delivered by the author at Moscow Technical Institute and published for the first time in 1911.

The book is broad in scope and presents the state of theoretical and experimental aeronautics at that time as reflected by a great scientific mind. Important contributions by Zhukovskiĭ to theoretical fields of knowledge (the theory of lift, to name one) need not be dwelt upon. Needless to say, the progress of aeronautics since 1911 does not appear in this work, thus limiting

its usefulness as an excellent historical reference book on this subject. A. Petroff, USA

Aeroelasticity (Flutter, Divergence, etc.)

(See also Rev. 2599)

2604. **Goodman, T. R., The quarter-infinite wing oscillating at supersonic speeds,** *Quart. appl. Math.* **10,** 189–192, 1952.

The title problem is solved via Gardner's method, the details of the analysis being similar to those of the author's solution for the gust problem [AMR **5,** Rev. 808]. The results agree with those obtained by the reviewer [AMR **4,** Revs. 329, 3629] and K. Stewartson [AMR **5,** Rev. 1138], but not with those of H. J. Stewart and T. Y. Li [AMR **4,** Rev. 1267]. The reviewer remarks that the errors in Stewart and Li's method [AMR **4,** Rev. 3628] recently have been discussed in some detail by Stewartson. J. W. Miles, USA

2605. **Collar, A. R., and Sharpe, G. D., A criterion for the prevention of spring-tab flutter,** *Aero. Res. Counc. Lond. Rep. Mem.* 2637, 17 pp., 1946, published 1952.

Paper presents a simple formula to be used as a criterion for degree-of-mass balance necessary to avoid spring-tab flutter. Theoretical considerations lead to relation between control inertias and follow-up ratio which must be smaller than a certain parameter. Value of parameter has been obtained from study of many actual tab systems. Formula also gives requirement for length of balance arm. Extension of formula is given for very large tabs.

Reviewer feels that, although paper is somewhat old, the formula proposed should be very valuable to designers. H. N. Abramson, USA

2606. **Wittmeyer, H., Theoretical investigations of ternary lifting surface—control surface—trimming tab flutter and derivation of a flutter criterion,** *Aero. Res. Counc. Lond. Rep. Mem.* 2671, 42 pp., Oct. 1948, published 1952.

Theoretical investigations have been made of the flutter of an idealized three-degree-of-freedom system which includes vertical translation of a wing, flapping of a control surface, and rotation of a trim tab. These calculations have been used to establish a criterion for prevention of flutter of a trim tab. Incompressible strip theory has been used for the air forces in this study. The criterion developed has been compared with those of the limiting cases of the Collar-Sharpe criterion and the Sharpe criterion for spring-tab flutter. Author's criterion appears to give somewhat less restriction on the design than the Sharpe criterion. He points out that the Collar-Sharpe criterion does not directly apply to this case and, hence, is not strictly relevant. A later Wittmeyer report is mentioned which will consider the spring-tab problem.

The paper is not easy to read since it assumes access to earlier work by the author. The results presented appear to have been well thought out and carefully done, and would appear to give a satisfactory criterion for tab flutter in the low Mach number range. In this day of high transonic and supersonic airplanes the criterion will, of course, be of little use except for those who are still designing low-performance private aircraft. The date of the report, October 1948, should be noted. J. E. Stevens, USA

2607. **Babister, A. W., Flutter and divergence of swept-back and swept-forward wings,** *Aero. Res. Counc. Lond. Rep. Mem.* 2761, 13 pp., June 1950, published 1953.

Equations of the flexural-torsional flutter of swept wings of the elastic cantilever type are deduced, assuming the wing to be fixed at the root, to possess an elastic axis at constant chord percentages measured normal to its leading edge, and to vibrate in the two degrees of freedom in phase and independent of the forward speed. In close agreement with experience, the two mode shapes are taken to be linear in twist and parabolic in bending. Numerical values for geometrical and inertia parameters of the systems studied, as well as for the aerodynamic coefficients, are deduced from experimental evidence. Compressibility effects due to variations in Mach number are taken into account in the usual manner by application of the Prandtl-Glauert rule.

Effect of sweepback and sweepforward on the critical flutter speed was determined and it was found that the latter is usually higher for sweptback wings. In addition, it is noted that for a sweptforward wing divergence will occur before flutter. Effects of various other parameter changes were carefully investigated. Among these were the effect of change of the flexural and torsional wing stiffnesses, the effect of change in location of the elastic axis, and the effect of compressibility. Among the numerous interesting conclusions reached by the analysis are the observations that the critical flutter speed increases rapidly with the elastic axis moving toward the leading edge, while the divergence speed remains fairly constant. The former effect is less pronounced in the case of sharply sweptback wings. M. A. Dengler, USA

Propellers, Fans, Turbines, Pumps, etc.

2608. **Betz, A., Energy conversion of compressible gases in cascades** (in German), *Forsch. Geb. Ing.-Wes.* (*B*) **18,** 3, 61–71, 1952.

A simple graphical method is presented for the calculation of the over-all changes in the properties of a compressible fluid flowing through straight or circular cascades of blades. The effects of nonparallel walls, blade thickness, losses, moving blades, and internal heating are approximately allowed for. Curves are given for $\gamma = 1.4$ and 1.3. Method has the advantage that the limiting conditions of flow are easily discerned. G. M. Lilley, England

2609. **Poincaré, L., Optimum pressure ratios of gas turbines or turbo reactors** (in French), *Bull. Assn. tech. marit. aéro.* no. 51, 201–220, 1952.

Optimum pressure ratios of a power plant, consisting of an intake diffuser, compressor, combustion chamber, turbine, and propulsive nozzle, are studied from two different viewpoints of maximum power and maximum efficiency. Cases discussed include a simple gas turbine, a ramjet, and a turbojet. Optimum pressure ratio for maximum efficiency is found to be higher than that for maximum power. T. Y. Toong, USA

2610. **Wallis, R. A., and Cumming, R. W., Industrial aerodynamics,** *J. Instn. Engrs. Austral.* **24,** 12, 221–229, Dec. 1952.

Authors present in simple terms some of the aerodynamic phenomena that are usually overlooked in the design of industrial ducting systems. Comparison of flow in both proper and improper design is illustrated by sketches. Four specific industrial duct installations are analyzed to illustrate the general principles of design. M. S. Macovsky, USA

2611. **Nakata, K., Researches on the nonaircraft gas turbine,** *Japan Sci. Rev.* **2,** 1, 63–86, Apr. 1951.

Article describes equipment in gas turbine laboratory of Transportation Technical Research Institute of Japan, and results of

some early postwar investigations. This laboratory, author indicates, is doing the leading research in the field in Japan. Although present equipment is admittedly inadequate, experiments are being conducted on a 2200-hp marine gas turbine, 400-hp and 1000-hp axial compressors, a 200-hp centrifugal compressor, low- and high-speed cascade tunnels, combustion apparatus for study of chamber design and basic problems in burning of liquid and solid fuels. The brief outline of preliminary results is not intended to present major technical contributions but rather to indicate that significant work on the gas turbine and its elements is in progress.

P. R. Trumpler, USA

2612. Coppage, J. E., and London, A. L., The periodic-flow regenerator. A summary of design theory, ASME Ann. Meet., New York, Dec. 1952. Paper 52—A-93, 17 pp., 6 figs.

Author reviews available analytical and numerical solutions for the effectiveness ϵ of periodic-flow regenerators. An exact solution is known for the special case where cold and hot flow-stream capacity rates C_c and C_h are equal, and where cold and hot gas-unit conductances $(hA)_c$ and $(hA)_h$ are equal. Author develops approximate closed-form solution based on the assumption of uniform temperature for each flow. This approximate solution is then used to study the effect of C_c/C_h on ϵ, and this information in turn used to extrapolate the results of the more exact solution $[C_c/C_h = 1 = (hA)_c/(hA)_h]$ into the useful range of $C_c/C_h < 1$.

Performance curves based on this extrapolation are presented in terms of four dimensionless design parameters.

P. J. Schneider, USA

2613. Neel, C. B., Jr., An investigation utilizing an electrical analogue of cyclic de-icing of a hollow steel propeller with an external blade shoe, *NACA TN* 2852, 54 pp., Dec. 1952.

The study shows how the energy requirement for propeller de-icing with existing blade shoes can be decreased, and illustrates the effect of blade-shoe design on the energy requirement. It is demonstrated, e.g., that by increasing the heating intensity and decreasing the heating period from those currently used, the energy requirement can be decreased in the order of 60%. In addition, it is shown that heating requirements can be decreased further, by as much as 60%, through proper design of the shoes. The investigation also shows the energy requirement to increase with decreasing liquid-water content and air temperature. Uncertainties as to the exact values of convective heat-transfer coefficient prevailing over the surface of the blade and ice layer result in uncertainties of approximately proportional magnitude in the values of required heating intensity.

From author's summary

Flow and Flight Test Techniques

(See also Rev. 2610)

2614. Pankhurst, R. C., and Holder, D. W., Wind-tunnel technique, London, Sir Isaac Pitman & Sons, Ltd., 1952, xviii + 702 pp. $10.

This volume deals with a topic that has received practically no attention by authors to date. It is, therefore, a very welcome addition to the literature on aeronautics, since it fulfills a long overdue need for a definitive work on the experimental methods used in aerodynamics. Although the present edition was published in 1952, the authors' preface is dated 1948, and most of the material was probably written at an even earlier period. As a result, subsonic-flow techniques have been emphasized and some established techniques in the compressible-flow field have been omitted. (The authors were aware of this difficulty, and added a few footnotes which are dated as late as 1951.) The techniques and refinements which are used in supersonic and hypersonic wind-tunnel studies would have enhanced the value of the present volume. Nevertheless, most of the material in the book is quite topical and fundamental.

Aeronautical research scientists, engineers, and students will find the subject matter useful and informative. The presentation is clear and scholarly. It is well documented and the references will be of considerable assistance to anyone interested in the relevant literature. Since the number of topics is extensive, each is of necessity treated in a concise manner.

The volume consists of the following twelve well-illustrated chapters and four appendixes: Chap. 1 is of an introductory nature, and deals with experimental concepts, definition of physical and thermodynamic quantities and nondimensional coefficients used in aeronautics.

Chap. 2 considers wind-tunnel design and gives some criteria for the design of basic components such as effusers, working section, diffusers, and power installations. Effects of turbulence, sound, wire screens, honeycombs, and contractions are discussed. Nozzle design methods are referenced but not evaluated in a critical manner. A good account is given of various types of wind tunnels, but these are not analyzed from an aerodynamic viewpoint.

Chap. 3 discusses the various methods of flow visualization. These include smoke generation, hot wire filaments, spark discharges, liquid film, china clay, tufts, optical and x-ray methods. Sixteen excellent plates containing flow photographs are included in this chapter.

Chap. 4 is devoted to the measurement of fluid velocity and is among the best chapters in the book. Bernouilli's equations for steady, isentropic, incompressible, and compressible flows are considered. Methods are given of measuring static and stagnation pressures; flow speeds from a hot wire anemometer; Mach number from cones and wedges; flow inclinations from yawmeters; mass flow from Venturis, orifices, and other methods, which are mainly limited to low-speed work.

Chap. 5 is devoted predominantly to subsonic types of wind-tunnel balances.

Chap. 6 discusses aerodynamic forces from measurements of static pressure distributions and total head surveys. Methods of obtaining lift, drag, moment, friction, and thrust coefficients are outlined.

Chap. 7 gives an excellent account of manometry techniques, which are mostly applicable to subsonic and low supersonic flows.

Chap. 8 is devoted mainly to wind-tunnel interference effects and their corrections in subsonic flow. The reviewer believes that Fig. 267 and the descriptive text, which attempt to employ the methods of images in supersonic flow for zero boundary constraint, are in error for flows with shock waves, owing to the nonlinear nature of the problem and complex shock boundary-layer interactions. Variable specific heats, condensation effects, and drying methods are also considered.

Chap. 9 deals with the reduction of observations and the presentation of data.

Chap. 10 indicates some of the more refined methods employed in research work on boundary layers, turbulence, stability and control, flutter, propeller thrust and torque, as well as ground effects.

Chap. 11 gives an excellent account of the electric tank and Hele-Shaw analogies and the surface wave analogy, which are utilized for the study of incompressible and compressible flows, respectively.

Chap. 12 deals with model designs and their rigging.

The four appendixes list various aerodynamic functions, properties of air, wire-screen data, pipe losses, conversion factors,

standard tubing, indexes of the British *Rep. and Mem.* and *NACA Tech. Reps*, electrical-resistance color code, airfoil notations, continental aerodynamic symbols, and a list of abbreviations. Readers will find some of these data redundant; nevertheless, they are useful for reference purposes.

The book has been carefully prepared and only two minor typographical errors were noted in the text. (Eq. 14, p. 178, ν should read p; p. 421, absorption should read adsorption.)

This volume will be most useful to the individual who has not received a wide experience in the arts and methods employed in research and testing. The reviewer would like to recommend this book to scientists, engineers, and students interested in the field of experimental aerodynamics. I. I. Glass, Canada

2615. **Jorissen, A. L., On the evaluation of the accuracy of the coefficient of discharge in the basic flow measurement equation,** ASME Ann. Meet., New York, Dec. 1952, Paper 52—A-144, 9 pp.

Paper gives a summary of present status of tolerance specifications for Venturi meter and thin-plate orifice meter coefficients. International, German, French, and American code tolerance proposals are discussed. Author suggests using a figure of 0.75% as a safe value for the tolerance on the coefficient of discharge of Herschel-type Venturi tubes for pipe diameters between 4 in. and 32 in. and Reynolds numbers above 200,000.

Proposed tolerances for the coefficient of discharge of thin-plate concentric orifices are presented as a function of pipe diameter (from 2 in. to 14 in.) for flange taps and for vena contracta taps. Author states these results are based upon experiments conducted in only one laboratory. The complete range of variables and results of the individual tests are not given.

Material on Venturi coefficient tolerances in previous papers [see AMR **4**, Rev. 4500; **6**, Rev. 529] is necessary for interpretation of present summary. H. W. Iversen, USA

2616. **Ludloff, H. F., and Friedman, M. B., Corrections for lift, drag, and moment of an airfoil in a supersonic tunnel having a given static pressure gradient,** *NACA TN* 2849, 69 pp., Dec. 1952.

The airfoil is two-dimensional and the tunnel has pressure gradients in both the axial and transverse directions. The tunnel gradients and the effect of the airfoil are regarded as perturbations of the original rectilinear flow field of given Mach number. Thus, the velocity potential of the flow, the nonlinear differential equation of motion, and the boundary conditions are expanded into double series in powers of two parameters, one characterizing the airfoil thickness and the other the inhomogeneity of the flow field. The nonlinear problem is consequently split into a system of linear boundary-value problems which are solved analytically. The solutions are given in closed form and are valid for arbitrary tunnel pressure gradient and for general airfoil shape.

From authors' summary by N. Tetervin, USA

Thermodynamics

(See also Revs. 2516, 2579, 2609, 2634, 2638)

2617. **Byushgens, S. S., The geometry of adiabatic flow** (in Russian), *Uchen. Zap. mosk. Univ.* **148**, *Matematika* **4**, 30–52, 1951.

This paper, dealing with stationary flows of an ideal weightless gas without friction and heat conduction, is a further exposition of the theory laid down in the previous articles [AMR **3**, Revs. 512, 744]. The fundamental equations are the Euler equation $(\bar{v}\,\mathrm{grad})\bar{v} + \rho^{-1}\,\mathrm{grad}\,p = 0$, continuity equation $\mathrm{div}\,(\rho\bar{v}) = 0$, and the condition $pp_0^{-1} = \rho^k\rho_0^{-k}$. The method used is that of the mobile trihedron, built sometimes of oblique, sometimes of orthogonal vectors [see Buscheguennce, *Izv. Akad. Nauk SSSR Ser. Mat.* **10**, 73–96, 1946]. The cases discussed include those of minimal and rectilinear congruences, potential and spiral flows. A surface is called critical if $v^2 - a^2 = 0$, minimal if $\mathrm{div}\,(\bar{v}/v) = 0$. Conditions are established for a congruence to be the congruence of streamlines of an adiabatic flow; these conditions involve the Mach number $\lambda = v^2a^{-2} - 1$. When an adiabatic flow admits a minimal congruence of streamlines, it is called a minimal flow; only for such a flow is the scalar velocity constant along every individual streamline. When the streamlines are orthogonal to a family of isobaric surfaces (ρ = const), then the flow is rectilinear.

Courtesy of Mathematical Reviews D. J. Struik, USA

2618. Saha, M. N., and Srivastava, B. N., A treatise on heat, 3rd ed., Allahabad and Calcutta, The Indian Press, Ltd., 1950, xii + 935 pp., 28 diagrams, 3 plates, 92 tables. Rs. 32.

This is a revised edition of authors' well-known "Textbook of heat," first published in 1931. The text has been rearranged, largely rewritten, and brought up to date with inclusion of the literature up to 1949. The authors call their book "an account" of the classical theory of heat, kinetic theory, statistical mechanics, and theory of thermal ionization, the last subject representing the field to which Professor Saha has made important contributions. By compressing between the covers of one book all these topics and several other more remotely related subjects such as heat engines or conduction and radiation of heat, this account could, in most cases, not be more than a survey of the various aspects of the science of heat; the reader who needs detailed information on any particular branch of this science has to consult one of the texts devoted especially to it, references to which are to be found throughout the book. In the desire to offer something to everybody—the book is addressed to advanced students, research workers, engineers, physical chemists, and astrophysicists alike—the text has more width than depth, and a subject of fundamental importance such as the modern theory of irreversible processes (phenomenological as well as statistical) has been entirely omitted, though an obsolete treatment of thermoelectricity is given on page 339.

The book has distinct advantages for the reader who uses it as an introductory text to the science of heat. Due to the way in which the material has been selected, it will give him a sense of unity of the various branches of this science which he will have difficulty in acquiring elsewhere; and due to the manner in which the presentation of experimental and theoretical material is interwoven, he will acquire from the beginning a feeling of the usefulness and the practical value of the theories which he is studying.

The following enumeration will give an idea of the wealth of material collected in the book: Thermometry, calorimetry, kinetic theory of transport phenomena, rarefied gases, three laws of thermodynamics, Maxwell relations, phase equilibria, statistical thermodynamics, van der Waals equation, virial theorem, phase changes, vapor pressure relations, liquefaction of gases, phenomena at liquid helium temperature, theories of specific heats, quantum-mechanical effects in thermodynamics, chemical reactions, including those at ionization temperatures, thermonuclear reactions. E. F. Lype, USA

2619. **Stocker, P. M., The transients arising from the addition of heat to a gas flow,** *Proc. Camb. phil. Soc.* **48**, 482–498, 1952.

The development of the one-dimensional flow pattern for the case of a uniform rate of entropy addition over a limited region may be solved with some difficulty by the method of charac-

teristics. The author proposes two linearizing approximations to investigate the transients preceding the steady state discussed by Foa and Rudinger [AMR **2**, Rev. 507]. The first assumes linear characteristics of constant slope which are sufficient to map out the transient flow regions and the pattern of transition to steady state. This, however, introduces serious errors at moderate Mach numbers in the behavior of the receding characteristics. An improved approximation leaves the advancing characteristics linear but introduces a first-order correction to the receding characteristics, using the rate of entropy addition as an approximation parameter. The several transient regions formulated explicitly for the linear approximation may still be described in explicit form, with several examples indicated. This first-order correction is shown to correct most of the error inherent in the linear approximation. N. A. Hall, USA

2620. von Zeerleder, A., Heat treatment of aluminum and its alloys (in German), *Schweiz. Arch.* **18**, 7, 8; 209–219, 255–264; July, Aug. 1952.

The different available fuels and heat-transfer agents are discussed from the point of view of economy and their influence on the heat treatment. The different types of furnaces, both charging type and continuous operating, that are used for the several stages of heat treatment are discussed in detail. The furnaces for annealing the ingots, soft annealing, solution annealing, and artificial heat-tempering as well as the modern ovens for short-time heating are described in special sections. The necessary equipment for measuring and controlling temperature is described. C. F. Peck, Jr., USA

2621. Yao, T. P., and Kondic, V., The viscosity of molten tin, lead, zinc, aluminium, and some of their alloys, *J. Inst. Metals* **81**, 17–24, 1952/1953.

An oscillating-pendulum method has been used to determine the viscosity of molten tin, lead, zinc, and aluminum as a function of temperature. The binary tin-zinc and tin-lead systems were also investigated, as well as the effect of titanium on the viscosity of aluminum, and of furnace atmosphere and holding time on the viscosity of zinc. Viscosity values for the pure metals agreed very closely with those generally accepted, except near the freezing point. When plotted against composition, at a constant degree of superheat, the viscosity of tin-zinc alloys showed maxima in the region of the pure metals and a minimum corresponding to the eutectic. Small additions of titanium appreciably increased the viscosity of aluminum, and the viscosity of zinc increased with time of exposure to the atmosphere. The viscosities of metals and alloys near the freezing point appear to undergo certain changes that may account for the anomalous behavior of the metals during fluid flow. From authors' summary

2622. Ramsey, J. A., The sub-grain structure in aluminium deformed at elevated temperatures, *J. Inst. Metals* **81**, 215–216, 1952/1953.

Subgrain structures in coarse-grained aluminum deformed at elevated temperatures are shown by metallographic and x-ray examination to be associated with bands similar to kink bands. A marked resemblance thus exists between these subgrain structures and those resulting from heating after straining at room temperature. From author's summary

2623. Schrock, V. E., Calorimetric determination of constant-pressure specific heats of carbon dioxide at elevated pressures and temperatures, *NACA TN* 2838, 46 pp., Dec. 1952.

The constant-pressure specific heat of carbon dioxide has been measured over the range of pressures and temperatures from ambient conditions to 1000 psig and 1000 F, using a steady-flow calorimeter operating on an open cycle. It appears that the apparatus as used in this determination will yield values with a probable error of 0.5% at the highest temperature level considered. The results of these tests check the widely accepted spectroscopic data within 1%. The values at elevated pressures are in reasonable agreement with those derived from the zero-pressure spectroscopic values and the application of the Beattie-Bridgman equation of state.

Only very limited calorimetric data are available in the literature, but substantial agreement exists with those considered reliable. From author's summary

2624. Wulff, J., Taylor, H. F., and Shaler, A. J., Metallurgy for engineers. Casting, welding, and working, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, 1952, viii + 624 pp. $6.75.

When recognized authorities in a particular field write a text at the undergraduate level, occasionally they do not have the best interest of the student at heart. Validity of theory, completeness of proofs, thoroughness of documentation, and elegance of mathematics sometimes hold sway, leaving the student baffled and confused. Such is not the fact in the case at hand. Here a careful study gives one the feeling that considerable thought and planning has gone into the preparation of the text to make the subject matter as clear to the student as possible. At the same time, modern concepts are used in the development of the subject matter. The result is that the treatment is logical, up to date, and rigorous.

As is pointed out in the Introduction, "Metallurgy for engineers" is intended as a textbook for engineering students and as a self-teaching book for practicing engineers. The reviewer feels that these intentions are amply fulfilled. The subject matter covers the general field of metallurgy, except that of extractive metallurgy. Roughly speaking, the book can be broken down into two subdivisions—principles and processes. Basic principles are first dealt with and include such things as crystalline structure, solidification, impurity and solubility, phase equilibrium, alloy systems of limited solid solubility, industrial nonferrous alloys, alloys of iron and steel, heat treatment of steel, heat-treating steel, methods for determining mechanical properties, mechanism of deformation and effects of deformation of controls, electrical and mechanical properties of metals, and corrosion. Under the general subject of metallurgical processes are included sand-casting processes, casting processes other than sand casting, the ingot as a casting melting—heat flow—gases in metals, casting defects—inspection—casting design, gating and risering, powder metallurgy, welding, arc-welding processes, gas welding, thermit welding, and metalizing, pressure welding, brazing and soldering, metal working, stretching, shearing and bending, and metal cutting.

Every effort is made in the interest of clarity and reader appeal. There are approximately 270 simplified and clearly labeled figures running along with the text. Paragraphs and chapters are short and the printed lines are widely spaced for easy reading. At the end of each chapter appears a chapter summary, giving salient points, questions, and references.

To the reviewer the book is an extremely well-done job. It is highly recommended to practicing engineers, whose background in metallurgy is weak, as a desirable starting point for bringing themselves up to date before attempting to plunge into the complex, specialized literature of current technical journals on the subject. In the training of undergraduate engineers, it is an excellent text in developing a sound, complete, and up-to-date understanding of the subject matter.

L. F. Coffin, Jr., USA

Heat and Mass Transfer

(See also Rev. 2585)

2625. **Satoh, T., On the mathematical analysis of the problem of heat conduction with variable transfer coefficient,** *J. phys. Soc. Japan* **7,** 3, 245–249, May/June 1952.

The paper is (overlooking several misprints) rigorously written mathematically, and, using almost all effective methods of classical analysis for the solution of the difficult title problem, is a valuable contribution to the theory of heat conduction.

It deals with the cooling of an infinite cylinder where the transfer coefficient h is variable with time. For technical purposes it would, of course, be possible to use a slightly modified Schmidt's graphical method, yielding a rapid solution, even for h as a function of surface temperature.

K. Rektorys and O. Maštovský, Czechoslovakia

2626. **Sugawara, S., Sato, T., and Kitao, M., Experimental researches on heat transfer on the surface of a flat plate in the forced flow, 3rd report** (in Japanese), *Trans. Soc. mech. Engrs. Japan* **18,** 72, 6–10, Aug. 1952.

2627. **Sugawara, S., Sato, T., and Tatsumi, T., Experimental researches on heat transfer on the surface of a flat plate in the forced flow, 4th report** (in Japanese), *ibid.*, **18,** 72, 11–16, Aug. 1952.

The third report concerns the roughened plates having parallel projections of a fixed height and of various pitches, and the fourth with the case of a variable height of the projections. Like the case of plates with grooves described in the second report [AMR 5, Rev. 2498], it is shown that above a certain Reynolds number, Nusselt number becomes nearly proportional to Reynolds number. Authors consider specifically the Nusselt number Nu' based on the effective surface area, taking into account the increase of area due to projections, and show that the ratio of Nu' to Re, Reynolds number, is maximum at the height-pitch ratio of about 0.055, and this maximum value increases with the height of the projections. The effect of projections on the heat transfer is shown to be somewhat larger than that of the grooves.

H. Tamaki, Japan

2628. **Buchberg, H., Romie, F., Lipkis, R., and Greenfield, M., Heat transfer, pressure drop, and burnout studies with and without surface boiling for de-aerated and gassed water at elevated pressures in a forced flow system,** Heat Transfer and Fluid Mechanics Inst., Stanford Univ., 177–191, 1951. $5.

A high-pressure, circulating flow system with an electrically heated heat-transfer tube was used to obtain heat transfer, pressure drop, and density data, with and without surface boiling, and to determine conditions for inception of boiling and for tube burnout. The range of variables covered by earlier investigators was extended to include pressures up to 25 psia, fluid temperatures up to 650 F, and heat flux densities up to 3.8×10^6 Btu/hr/ft^2. With the results of this investigation, briefly summarized in this paper, it is possible to predict with reasonable accuracy, for a wide range of variables, heat-transfer and pressure-drop phenomena in systems similar to the one employed.

From authors' summary

2629. **Levy, S., Theory of pressure drop and heat transfer for annular steady state two-phase two-component flow in pipes,** Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 337–349, 1952. $6.

A core of gas is surrounded by an annular ring of liquid. Three cases are considered, laminar-laminar, turbulent-laminar, and turbulent-turbulent gas-liquid regimes; pressure drop and heat transfer are worked out for each. Navier-Stokes equations are used for laminar and one-seventh power law for turbulent flow. Shear stress is continuous at the interface.

Author concludes that the parameter X used by Martinelli in experiments on this problem (namely, the square root of the ratio of pressure if liquid flowed alone to that if gas flowed alone) is adequate theoretically. However, experimental values of pressure drop and liquid saturation always exceed theoretical, former by 20%. This is thought to be due mainly to interface waves in experiments.

Paper is typed and written formulas are often illegible. Moreover, notation is infuriatingly inconsistent; e.g., in handwritten work we have R_L, in typed R_1, and in diagrams R_l. There is also a different function R suffix unity, written R_1, just to add to the confusion.

J. C. Cooke, British Malaya

2630. **Jacklin, C., Experimental studies of boiler tube metal temperatures: effect of heat-transfer rate and deposit thickness,** Ann. Meet. ASME, New York, Dec. 1952. Paper 52—A-30, 16 pp.

Paper attempts to show the effects of deposits on the over-all heat-transfer coefficient of a boiler tube. The deposits are on the water side of the tube and the types of deposits investigated are: Analcite, magnesium phosphate, magnetic iron oxide, and calcium phosphate.

The findings of Mr. Jacklin can only be considered qualitatively. In the opinion of the reviewer, the experimental treatment could have been carried out in greater detail in order to obtain more convincing results.

S. Eskinazi, USA

2631. **Orr, C. Jr., The transference of heat between a pipe wall and a liquid-solid suspension following turbulently inside the pipe. The thermal conductivity and viscosity of a liquid-solid suspension,** Thesis, Georgia Inst. Technol., 160 pp., Dec. 1952.

2632. **Price, P. H., and Slack, M. R., Stability and accuracy of numerical solutions of the heat flow equation,** *Brit. J. appl. Phys.* **3,** 12, 379–384, Dec. 1952.

Various methods of solutions of the heat-flow equation are presented and the accuracy of the finite difference solution for certain boundary conditions is investigated. Stability criteria for the approximate methods of solution are postulated. The boundary conditions along the surface of a slab are given in equation form. This equation is transformed in different ways in the various finite difference methods of solution (I–VI). The accuracy of the six methods is estimated and their results compared with those of the analytical solution. One method of solution is compared with that of Crank and Nicolson. It is stated that the heat-flux boundary conditions might have adverse effects on the stability of solutions.

Reviewer believes that, since stability is well-defined in mathematics and physics, the use of this word to describe approximate solutions which either have or do not have solutions with discrete oscillations about the exact solution is wrong. In addition, stability is used in the paper often to describe conditions not related to actual stability. Convergence or divergence should be used to describe the behavior of approximate solutions.

T. P. Torda, USA

2633. **Scherrer, R., Comparison of theoretical and experimental heat-transfer characteristics of bodies of revolution at supersonic speeds,** *NACA Rep.* 1055, 15 pp., 1951.

Author summarizes and reconsiders work presented in *NACA*

RM A2L28 and *NACA TN* 1975, 2087, 2131, and 2148. Subjects treated include temperature recovery factor, heat transfer, and boundary-layer transition under conditions of heating and cooling for cones and parabolic bodies of revolution. Mach number range considered is 1.5–2.0. M. W. Rubesin, USA

2634. Handbook on refrigeration [Handbuch der Kältetechnik], 12 vols., Karlsruhe, R. Planck, 1953, 4800 pp.

Acoustics

2635. Brillouin, J., Radiation problems in architectural acoustics (in French), *Acustica* **2**, 2, 65–76, 1952.

Two problems are considered: The transmission of sound by flexural vibration of floors, ceilings, and walls; and the effect of polycylindrical diffusers on reverberation time. The first problem, which receives the greatest attention, is treated analytically for an infinite plane lamina backed by air. If the velocity of flexural waves is greater than that in air, then the panel radiates plane waves into the air at an angle whose sine is the reciprocal of the index of refraction. For slower flexural waves, there is no radiation. The aerial disturbance attenuates rapidly with distance from the panel, and the trajectory of the air particles is an ellipse with major axis parallel to the direction of the flexural wave. Because of the attenuation, the position of the microphone is critical for measurements of this sort. Since the velocity of flexural waves varies as the square root of the frequency, for a given panel there will be a critical frequency below which it will not radiate (in flexural vibration). For two plaster panels investigated, the critical frequencies were 680 and 3080 cps, which indicates the order of magnitude. In the experimental tests, standing waves are present but these may be considered as superposed progressive waves. Hence, the critical frequency still divides radiating and nonradiating regions.

An associated problem is that of a light false ceiling suspended by a multiplicity of tensile members from a heavy floor. Approximate analysis indicates that, for best sound isolation, the critical frequency of the floor should be as great as possible and the suspending members should be weak springs spaced as widely as possible.

In the second problem considered, reverberation times were measured in rooms similar except for polycylindrical diffusers on the walls of one room. Repetitive impact and continuous sinusoidal sound sources were used, and the reverberation times were obtained in octave bands. For the plain room, the times for the two sources were equal; in the diffusing room, the average reverberation time for impact excitation was about 46% of that for sinusoidal excitation. Thus, if measurements of transient sounds are to be made in rooms calibrated by sinusoidal signals, then the room should be free of diffracting centers if the calibration is to be valid. V. Salmon, USA

2636. Bordoni, P. G., Absorption of ultrasonic waves in solids (in Italian), *Atti Conv. Internaz. Ultracust.* **1950**, 135–143, 1951.

Theoretical discussion is given for absorption of sound waves in solids. Author investigates the dependence of attenuation on thermal conductivity and on viscous losses at the interface of crystals and in the interior of crystals. Effect on attenuation of each of above variables is characterized by a respective relaxation time at which absorption is maximum. Author also discusses dependence of relaxation time on temperature, as well as dependence of attenuation constant on both frequency and temperature.
O. K. Mawardi, USA

2637. Paolini, E., The propagation of ultrasonic waves in the sea (in Italian), *Atti Conv. Internaz. Ultracust.* **1950**, 402–415, 1951.

This paper was presented at the International Congress on Ultrasonics, held in Rome in 1950; it came under the section entitled "Engineering applications"; hence, author's approach is practical rather than theoretical. Author gives a rapid review of the phenomena which distinguish sound propagation in the sea from propagation in an ideal medium. He discusses different causes of attenuation; refraction resulting from the presence of steady currents and of sound velocity gradients; scattering caused by the presence of small particles and other impurities; and local power fluctuations. M. C. Junger, USA

2638. Barducci, I., Ultrasonic testing of metallic alloys (in Italian), *Atti Conv. Internaz. Ultracust.* **1950**, 347–358, 1951.

Author discusses experimental data on the mechanical properties of binary alloys as obtained by ultrasonic testing techniques. The principal parameter investigated is internal damping, and examples of its dependence or frequency, grain size, temperature, and composition are given. Some data on the elasticity modulus, density, and electrical conductivity are also given. Author concludes that the ultrasonic testing methods have sufficient sensitivity to composition to warrant further studies.
L. S. G. Kovasznay, USA

2639. Hillier, K. W., The application of ultrasonics to the measurement of the elasticity of high polymers, *Atti Conv. Internaz. Ultracust.* **1950**, 213–217, 1951.

The solidity of high polymer material is determined by its elastic properties. However, there is a considerable dependence on the rate of application of the deforming forces. Particularly, the loading time influences the elasticity because of the long-chain molecular structure of the material. The temporal variability covers a space from 10^3 sec to 10^{-6} sec. The research of short-time loading is successfully carried out by acoustic methods.

Paper describes an ultrasonic arrangement for testing a high polymer filament by a phase difference method. Measurements of phase shift and amplitude ratio furnish the propagating velocity and the attenuation. The correlations of these quantities with the elasticity are improved by the existing theories, but no resolved interpretation can be given because velocity and attenuation relations to stress, strain, and time are surely more complicated than theory can comprehend.
P.-P. Heusinger, Germany

2640. Vogel, T., On the boundary conditions of the equation of sound (in French), *Acustica* **2**, 6, 281–286, 1952.

A mathematical investigation studies the boundary conditions which the space-dependent factor of a solution of the equation of wave motion must satisfy at the boundary of the room or hall considered. The notion of a specific normal impedance [C. M. Harris, *J. accoust. Soc. Amer.* **17**, 1, 35–45, July 1945] does not lead to satisfactory agreement with experiments performed in author's laboratory with waves which are not incident nearly normally. It is suggested that the concept of a specific tangential impedance, in addition to the normal impedance, be introduced. R. Heller, USA

2641. Lange, Th., Ultrasonic methods of investigation in the phenomenon of vibration cavitation of fluids (in German), *Akust. Beihefte* no. 2, AB75–AB82, 1952.

A high intensity sonic field is generated in water by means of a quartz crystal (300; 575; 800 kcps). Cavitation then sets in at the nucleus bubbles, which oscillate nonlinearly. Their sound

radiation causes noise. The sound pressure is measured by a hydrophone. The critical point at which cavitation then commences is determined in the following ways: (1) From the discontinuity in the curve of microphone voltage (transmitting frequency) against transmitter voltage; (2) from the observed formation of bubbles; (3) from the commencement of a high-frequency noise, which is analyzed from 60 to 1100 kcps; (4) from the commencement of low-frequency noise, in which case the hydrophone can be employed at the same time for measuring the radiation pressure for amplitude-modulated ultrasonic radiation; (5) from the formation of peaks of high pressure which can be visually demonstrated, using a wide-band amplifier and an oscillograph. The important influence of the size of the nuclei on the tensile strength and on the onset of cavitation is determined experimentally.

From author's summary

2642. **Harrison, M., An experimental study of single bubble cavitation noise,** *David W. Taylor Mod. Basin Rep.* 815, 20 pp., Nov. 1952.

An experimental study of the noise produced by a single cavitation bubble has been made. The noise consists principally of a transient pressure pulse associated with the collapse of the bubble. The motion of the bubble has been photographed simultaneously with the measurement of the pressure pulse.

From author's summary

2643. **Anderson, A. B. C., Dependence of Pfeifenton (pipe tone) frequency on pipe length, orifice diameter, and gas discharge pressure,** *J. acoust. Soc. Amer.* **24,** 6, 675–681, Nov. 1952.

Measured dependences of the Pfeifenton frequency on static flow pressure, orifice diameter, and pipe length are presented, based upon studies of air flowing through pipes terminated in various orifices. Frequency measurements were made of the vibrations inside the pipe. The Pfeifentöne are not a series of discrete single-valued harmonics. Each covers a range of frequencies, any specific value of which is determined by the discharge flow velocity or pressure. When the orifice diameter approaches zero, the behavior of the primary Pfeifenton frequencies is as if they were produced by an open-closed organ pipe; when the orifice diameter approaches that of the pipe, the behavior is as if they were produced by an open-open organ pipe. A mechanism for the excitation of the Pfeifentöne is proposed.

From author's summary

2644. **Taylor, H. O., Tube method of measuring sound absorption,** *J. acoust. Soc. Amer.* **24,** 6, 701–704, Nov. 1952.

Description of a tube method of determining the sound-absorbing power of materials in which no exploring device is introduced in the path of the sound wave in the tube. The method is an extension of a research by Kennelly and Kurokawa on "Acoustic impedance and its measurement," and makes use of the motional impedance of a telephone receiver which serves as both the source of the sound wave in the tube and as the means for determining the fraction of sound absorbed by the material, a sample of which is attached to the piston which slides in the tube. Sample calculations for sound absorption are included.

From author's summary

Ballistics, Detonics (Explosions)

2645. **Urbański, W. S., Method for the calculation of flight trajectories of projectiles** (in Polish), *Arch. mech. stos.* **3,** 3/4, 217–224, 1952.

Author considers a method for computing trajectories of projectiles known to ballisticians from the time of Euler. However, he points out that sufficient attention has not been paid to the fact that of the two parameters in the two-parameter family of curves obtained, only one of them is essential, giving the form of the curves; the other is a scale factor. Hence, by calculating a sufficient number of such trajectories, one can easily solve many concrete problems of exterior ballistics.

It is assumed that the resistance due to air is a function of the velocity v and is directed along the tangent of the trajectory. This resistance can be written as $-cmF(v)$, where c is the ballistic coefficient, depending on the form and size of the projectile and is proportional to the density of the air; m is the mass of the projectile. For aerial bombs, $F(v)$ can be taken equal to av^2. It is easily shown that the components of velocity satisfy the system of equations

$$dv_x/dt = -cF(v)v_x/v, \quad dv_y/dt = -cF(v)v_y/v - g$$

After making a change of independent variables from t (time) to τ (angle made by the tangent to the trajectory with the horizontal), the preceding equations are transformed into ones that are readily integrable. If u represents the velocity at the summit of a trajectory, then the author shows that the family of trajectories depends on two parameters, b (the ballistic coefficient) and q (the reduced velocity at the summit). Of these, q is the essential parameter giving the forms of the trajectories. The calculation of these curves is facilitated by introducing the notions of "reduced velocity," "reduced time," and "reduced coordinates."

Author points out that his method is simpler than that of Garnier, Haag, and Marcus which was used in Poland before World War II.

E. J. Scott, USA

Soil Mechanics, Seepage

(See also Revs. 2494, 2502)

2646. **Schoklitsch, A., Soil mechanics, 2nd ed. [Der Grundbau],** Wien, Springer-Verlag, 1952, xii + 457 pp., 782 figs., 43 tables. $20.70.

Schoklitsch's "Soil mechanics" has long been regarded as a classic in its field. The second edition, while extensively revised and enlarged, indicates relatively little progress in soil mechanics since the date of the first edition (1932). While in recent years civil engineers have placed greater emphasis on the science of soil mechanics, the test methods and procedures used have changed but little. In fact, basic details of soil mechanics remain the same today as when first propounded by the great Rankine almost a hundred years ago.

All this does not deny that credit is due Dr. Schoklitsch. His book is a comprehensive work, skillfully done, with attention to detail rarely seen in the majority of engineering texts. He builds solidly on first principles and amplifies with practical considerations, giving a wide variety of examples. Almost every page contains two or more line drawings or illustrations, and tabulated data are numerous and designed to be useful. Important topics discussed include flow of underground water and seepage, pressure effects and thrusts on retaining walls, design and construction details for handling all sorts of soil-engineering problems, pile driving, coffer dams, etc. Much attention is given to laboratory testing of soil samples as well as methods of collection.

As a basic text, this edition should make a standard reference work for many years to come. However, it is primarily devoted to an exposition of European practice, with relatively few remarks concerning procedures used in the United States. It also misses much in its failure to describe advances made in the United

States on under-river and harbor tunneling, skyscraper foundations, as well as recent developments in geophysics pertaining to the evaluation of subsurface structure. There is also no discussion of earth shocks and vibrations. These shortcomings are not serious and the author is to be commended for his contribution. Along with Terzaghi, Schoklitsch shares the honor of having founded the modern school of soil mechanics.

J. M. DallaValle, USA

2647. Bažant, Zd., Jr., Graphical solution of the stability of permeable subsoil below a weir (in Czech), Anniv. Vol. Zdeněk Bažant, Praha, Technic.-Vědec. Vydavat., 31–42, 1952.

Author solves the problem of stability of permeable soil under a weir assuming that, in limit state of equilibrium, a circular slip surface is formed in the ground. The following forces are supposed to act on the segment between slip surface and the upper surface of ground: weight of ground and the contained water, piezometric pressure on the whole boundary of segment, and the internal friction along the circular surface. In the limit state, internal friction must hold balance to the other forces. Piezometric pressure is determined from the known equations of motion of fluid through a permeable soil. Weight of weir is not taken into account as the weir is supposed to bridge the place of failure.

As the author states, the assumption of the existence of the slip surface cannot be directly checked by an experiment and is only a working hypothesis. The conclusions drawn from this hypothesis agree with the experiments made by the author [cf., e.g., "Proc. Sec. Int. Conf. Soil Mechanics," 1948, Rotterdam].

Dragoš Radenković, Yugoslavia

2648. Sokolovskiĭ, V. V., On an approximate method in statics of granular media (in Russian), *Prikl. Mat. Mekh.* **16**, 2, 246–248, Mar./Apr. 1952.

It is shown that the solution of problems concerning the limit equilibrium of granular media can be replaced—as an approximation—by the sum of (1) the solution of the same problem for granular media with internal friction and with cohesion, but without any weight of its own; and (2) the solution of the problem for granular media with internal friction and with weight of its own, but without any cohesion.

Equations are derived and an example is given to illustrate the application of this method. G. P. Tschebotarioff, USA

2649. Barber, E. S., and Sawyer, C. L., Application of triaxial compression test results to highway soil problems, "Triaxial testing soils bitum. mixtures," *ASTM Spec. tech. Publ.* no. 106, 228–247, 1951. $3.50.

Certain variables in equipment and procedure influence the results obtained in the triaxial compression test. The effect of some of these variables are discussed in this paper. Limited data showing a comparison of results obtained in direct shear, and triaxial compression tests are also reported. Finally, a comparison is made of values obtained by bearing tests and those obtained by calculation from triaxial-test results.

From authors' summary by J. A. Cheney, USA

2650. Cambefort, H., Gravel alluvium in foliation and pervious formations (in French), *Trans. Fourth Congr. Irter. Comm. Large Dams*, New Delhi, Jan. 1951 (in 4 vols.), vol. IV, 431–446. $48 per set.

2651. Handa, C. L., and Singh, R., The role of Kankar and Kankar lime in India's development projects for dams and hydraulic structures, *Trans. Fourth Congr. Inter. Comm. Large Dams*, New Delhi, Jan. 1951 (in 4 vols.), vol. III, 411–443. $48 per set.

Micromeritics

THE FOLLOWING PAPERS (REVS. 2652–2657) WERE PUBLISHED IN *Trans. Fourth Congr. Inter. Comm. Large Dams*, New Delhi, Jan. 1951, 4 vols. $48 per set.

2652. Fox, C. S., The transportation and depositing of solid materials by flowing and evaporating water, vol. IV, 29–46.

Author points to the importance of the removal of solid matter by flowing water—as dissolved matter, as suspended silt, and as material rolled along the bed of a stream. The last item or bedload is rarely seen in movement since it occurs only when the river is in flood and muddy. He points out that where a chain of dams is built, as in the Colorado River, each reservoir becomes a silt trap, but that, nevertheless, the clear overflowing water from each dam immediately removes the alluvial material downstream. This alluvial material was original bedload, but now as no replenishing supply comes past the dams, the water carries off the bedload it normally carried (but which was originally replaced from the next reach upstream) during floods. The author has given the example of the pebble or shingle bank, known as the Chesil Beach, which establishes beyond all doubt the movement of pebbles from Budleigh Salterton, under Lyme Bay to the beach near Bridport and so out to Portland Bill, where the pebbles disappear into the sea. The distance is over 50 miles in all from the source, the cliff of Triassic Bunter Pebble Beds, to where the waves and undertow finally drag the pebbles into the floor of the English Channel. From author's summary

2653. Pick, L. A., Sedimentation problems in the Missouri River Basin, vol. IV, 47–68.

2654. Cassidy, W. C., The debris problem in the Los Angeles area and its control, vol. IV, 69–92.

2655. Lane, E. W., Sediment deposits in flood control and multipurpose reservoirs, vol. IV, 93–102.

2656. Maddock, T., Jr., and Borland, W. M., Sedimentation studies for the planning of reservoirs by the Bureau of Reclamation, vol. IV, 103–118.

2657. Nizery, A., and Rousselier, M., Economical aspect of the sedimentation in reservoirs (in French), vol. IV, 297–320.

The authors remind us first of all of the laws concerning the sediment filling of reservoirs, and apply the theoretical concepts to the case of the reservoir of Serre-Ponçon on the Durance river.

Referring to the studies of Masse and Gignet, they establish the theoretical expression of the value of a reservoir given to silt formation. They show how to appraise the economical value of ways to avoid silt formation (increment of the initial capacity of the reservoir above the optimum storage, mire removing by means of density currents, reforesting of the basin and correction of the mountain streams, mechanical extraction of deposits, use of the Monitor or a drifting tank ahead of the reservoir). The authors then study the case of daily storage reservoirs given to strong sedimentation.

This original and interesting study allows us to evaluate the economic significance of silt formation and its financial consequences. It clearly shows the relative merit of the various means of fighting these phenomena and the net production of some of them. In case of daily storage reservoirs, operating at two water levels is a safe solution recommended by the authors.

L. Escande, France

Geophysics, Meteorology, Oceanography

2658. **Kishinouye, F., On the period and the amplitude of microseismic movement,** *Bull. Earthq. Res. Inst., Tokyo* **29,** 3, 483–486, Sept. 1951.

Author applies instrument designed by himself to study of microseisms at Tokyo. He gives evidence of two types of microseisms; the first of 4-sec period and amplitudes up to 10 μ, and the second of 6-sec period and larger amplitudes. Brief discussion is given. K. E. Bullen, Australia

2659. **Roseau, M., Contribution to the theory of gravity waves of liquids of variable depth** (in French), *Publ. sci. tech. Min. Air, Paris* no. 275, 89 pp., 1952.

Methods to determine the potentials which represent the small harmonic oscillations in a liquid layer over a sloping bottom are developed for two-dimensional as well as a three-dimensional case. The results were published previously in 7 Notes in *C. R. Acad. Sci. Paris*, 1950–1952, and reviewed in these REVIEWS.

W. S. Jardetzky, USA

2660. **Smolyakov, P. T., On the conservation of a baric field** (in Russian), *Izv. Kazan Filial. Akad. Nauk SSSR Ser. Fiz.-Mat. Tekh. Nauk* **2,** 93–99, 1950.

2661. **Lacombe, H., The diffraction of as well. A practical approximate solution and its justification,** "Gravity waves," *Nat. Bur. Stands. Circ.* 521, 129–140, 1952. $1.75

Paper presents an approximate solution of the diffraction of swell at any angle of incidence by a gap in a breakwater into a harbor of infinite extent. Author adopts the boundary conditions corresponding to Kirchhoff's optically black surface for the breakwater, and assumes that the motion of water across the line of the gap is that of the swell undisturbed by the presence of the breakwater. The solution of the problem is given in terms of a curve analogous to Cornu's spiral.

Author considers in some detail the case of a swell diffracted by the end of a mole and the case of diffraction by a narrow gap a few wave lengths wide. In the last case, a diagram is given showing contours of constant amplitude. No comparison is given with the results of model experiments or with full-scale observations. J. M. Jackson, Scotland

2662. **Pierson, W. J., and Marks, W., The power spectrum analysis of ocean-wave records,** *Trans. Amer. geophys. Un.* **33,** 6, 834–844, Dec. 1952.

As authors state, observed pressure or surface fluctuations may be usefully regarded as segments of a stationary random process described by the distributions of (1) spectral energy, and (2) ordinate probability. This view at once refers a finite-length record to a parent process and provides a means of estimating the latter's spectral (power) density function, through Fourier inversion of estimated process correlation function. Authors adopt a randomness model [see also G. Birkhoff and J. Kotik, Proc. U. S. Nat. Bur. Standards Semicent. Symp. Gravity Waves (G.P.O.), 221–234, 1952], giving formulas for spectrum estimate, together with practical design relations enabling one to balance desired statistical reliability and resolving power of spectrum analysis against required computing labor. A Gaussian process (distribution of 200 measured ordinates partially checks this) with absolutely continuous spectrum is assumed. Using method and design formulas of J. W. Tukey [Symp. appl. Autocorr. Anal. Phys. Problems, 47–67, 1949], authors estimate 30 points on spectrum curve for a 25-min pressure record taken at 32.5-ft depth, extending results by classical hydrodynamic theory to surface fluctuation. Results appear to agree better with physical intuition than some machine-produced spectra, whose irregular appearance authors attribute to too-short data records and too-high attempted resolving power. F. R. Putz, USA

2663. Russell, R. C. H., and Macmillan, D. H., Waves and tides, London, New York, Melbourne; Hutchinson's Sci. Tech. Publ., 1952, 348 pp. 25s.

Engineers and engineering students who plan to concern themselves in any way with ships, harbors, oceans, or estuaries will find this book of great interest and value, as will the meteorologist and geophysicist. It will probably be less satisfactory to the layman on the one hand and to the trained oceanographer on the other. Although supposedly written for the intelligent lay person, the very nature of the subject matter requires an elementary grounding in college physics and especially in the rudiments of simple harmonic motion.

The volume actually consists of two separate books by each of two authors, bound together under the same cover and connected only by the fact that the subject of waves and the subject of tides are related, both in underlying physical principle and in concomitance of occurrence in the oceans.

The section on waves, by Russell, is well and clearly written. Classical concepts of the "ideal wave" are well explained. In those areas where the ideal-wave theories are inadequate and recent and controversial theoretical work is under way, the author honestly points up the differences in consequence, the inadequacies of each theoretical approach, and the discrepancy between theory and observation. This is carried off without confusing the reader, and the documentation of references is sufficiently good so that the reader who is only tantalized by the brief outline of the theoretical procedures may go on for himself. In those places where theories are most inadequate, the writer does well in presenting the empirical procedures followed, and throughout the section a fine job is done in illustrating by concrete examples and sample calculations. A good feeling for orders of magnitudes runs throughout. For engineering purposes, the discussion goes beyond most popular presentations by containing two fine chapters on movement of material by the sea and the effect of wave action on structures.

The section on tides by Macmillan is hampered by the considerably greater difficulty of the subject matter, by a more restrictedly British approach (with most examples limited to British waters and documentation confined to British works) and by a necessarily more "practical" attitude, since tidal research has not recently gone forward so fast as that concerning waves.

Nevertheless, a very fine attempt has been made in the chapter entitled "Tidal theory today" to make comprehensible the long transition in thought between the classical picture of the all-water earth with two tidal bulges and the observed behavior of tides in oceans, coasts, and estuaries. The chapters entitled "Tides and the weather," "Tides and the navigator," etc., will be of value to the engineer. The final chapter on future of tidal research fails to take into account promising investigations being carried on now by American institutions, but does point out the great need for deep-water observations before significant progress in tidal theory can be made.

Joanne Starr Malkus, USA

2664. **Priestley, C. H. B., and Sheppard, P. A., Turbulence and transfer processes in the atmosphere,** *Quart. J. roy. Meteor. Soc.* **78,** 338, 488–529, Oct. 1952.

A brief but excellent summary of theory and observations of turbulence and transfer theory for the atmosphere, digested for the meteorologist. The discussion includes several wind-tunnel

experiments which have a bearing on atmospheric turbulence. Derivations are omitted, although some mathematics is included.

While it is the authors' intent to cover all scales of turbulence, including those on a synoptic scale, most of the paper deals with "earthbound" and "small scale" eddies. The almost total lack of knowledge on the scale between the smallest (about 1 kilometer) and the largest (500 kilometers or more) is reflected by the negligible space devoted to it, and even the Grossaustausch is discussed but briefly. The absence of an equivalent vertical Grossaustausch is noted for both the troposphere and the stratosphere. It would have been fruitful for the authors to have speculated on the role which turbulence might play in the current attempts at numerical forecasting.

The review is particularly valuable in evaluating the more recent investigations of Kolmogoroff, Onsager, etc., on the similarity hypothesis. The latter, as well as the papers of Batchelor, have been too obscured by mathematics to be intelligible to most meteorologists. The theory is explained and its potential placed in its proper light for explaining atmospheric turbulence phenomena. The reviewer is still puzzled by the apparent validity of the 4/3 law ($K \propto \epsilon^{1/3}\eta^{4/3}$) through all eddy sizes in the atmosphere despite its supposed derivation for the isotropic inertial eddy range. L. Machta, USA

Lubrication; Bearings; Wear

2665. Levinsohn, M., and Reynolds, N. E., III, Experiments with water-lubricated tapered-land thrust bearings, Ann. Meet. ASME, New York, Dec. 1952. Paper 52—A-29, 12 pp., 11 figs.

Their load-carrying capacity is tested for light loads and moderate speeds (i.e., on sealed pumps). The bearings were unidirectional and manufactured from a commercial bearing grade of carbon (scleroscope hardness 75) in form of flat rings, 1/2 in. thick, 2 3/4 in. OD, 1 3/4 in. ID, provided with lubricant grooves extending radially to within 1/32 in. of the outer periphery. Preliminary tests attempted the use of 4, 6, 8, 12 grooves. Six grooves proved to be the best. Then 9 designs were proposed with radial taper 0; 0.0002; 0.001; circular taper 0.0003; 0.0005; 0.001. The bearings were tested at 430, 860, 1725, 3450 rpm by gradually loading them to 110 psi. The lubricant was distilled water at room temperature (visc. 0.72 to 0.96 cP). Temperature and bearing torque were measured. The coefficient of friction was plotted vs. ZN/P. The curves show the usual shape. The greater the circular taper the lower the coefficient of friction, but bearings with 0.001 taper proved unable to carry heavy loads at low speeds. Good designs incorporate six grooves, circular taper in 2/3 or 3/4 of land area 0.0006 in. to 0.0008 in. deep in the lowest point, radial taper 0 to 0.0003. The tapers were manufactured by means of a special cutting jig working in connection with a drilling press. This press was also a component of the test machine. F. Budinský, Czechoslovakia

2666. Kozacka, J. S., Erickson, H. A., Highriter, H. W., and Gabriel, A. F., An investigation of cemented tungsten carbide as bearing material, Ann. Meet. ASME, New York, Dec. 1952. Paper 52—A-45, 12 pp., 12 figs.

Tests on 0.312-in. diameter split journal bearings using different lubricating oils under varying load conditions yielded the following results: (1) Pressures to 5000 psi could be supported with kerosene as lubricant without indications of seizure or scuffing; (2) galling occurred when run dry under a load of 884 psi; (3) coefficients of friction increased with increasing surface roughness indicating that surface asperities were in contact; (4) E.P. additives significantly reduced coefficients of friction, especially for bearings with rougher surface finishes; (5) the neck of the ZN/P against f curve occurred at higher values of ZN/P with rougher surface finishes; (6) no serious damage occurred in a bearing run for 320 hr under loads up to 1765 psi.

Reviewer believes that scuffing tests should have been stopped at intermediate loads for visual examination. Since bearing was run at each intermediate load for just one minute, slight galling which would limit life may have occurred at loads below the reported limiting value. In addition, bearing lengths should be reported. W. J. Anderson, USA

2667. Johnson, R. L., Swikert, M. A., and Bisson, E. E., Effective lubrication range for steel surfaces boundary lubricated at high sliding velocities by various classes of synthetic fluids, *NACA TN* 2846, 23 pp., Dec. 1952.

Synthetic lubricants are necessary to satisfy the physical property requirements for future lubricants of aircraft turbine engines. The effects of a wide range of sliding velocities on boundary lubrication were studied.

Sliding-friction data and surface-failure properties show that a number of synthetics including diesters, polyethers, a silicate ester, and a phosphonate ester as well as a silicone-diester blend are more effective boundary lubricants at high sliding velocities than comparable petroleum oils. The blend of a diester in silicones, an alkyl silicate ester, and a compounded diester (containing lubrication additives) were more effective boundary lubricants at high sliding velocities than the comparable diesters from which the most widely accepted synthetic lubricants are made. A diester failed to lubricate nonreactive surfaces, which indicates that the lubrication mechanism for diesters may involve chemical reaction with the lubricated surfaces.

From authors' summary

Marine Engineering Problems

2668. Blanchard, U. J., The planing characteristics of a surface having a basic angle of dead rise of 40° and horizontal chine flare, *NACA TN* 2842, 26 pp., Dec. 1952.

The basic hydrodynamic parameters of resistance, center of pressure, draft, and wetted length were determined for a flared prismatic planing surface of 40 degrees deadrise. To effectively cover the range of trims and loads of significance in the design of high-speed water-based aircraft, combinations of trims up to 30° and loading coefficients up to 87.0 were investigated to a Froude number of 25.0.

The data indicate that increasing the basic angle of deadrise of a horizontally flared surface from 20° [*NACA TN* 2804] to 40°, decreases the ratio of center-of-pressure location to the mean wetted length from 0.67 to 0.62, decreases the amount of pile-up of water at the keel, increases the range of trim over which friction resistance is appreciable, and increases the wetted area required to support a given load. E. G. Stout, USA